AD NUMBER
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AD8 15629

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RDT&E PROJECT NO. 1X141806D134-04
USATECOM PROJECT NOS. 4-4-1542-06
4-4-1542-09
USAAVNTA PROJECT NOS. 65-12
66-09

ENGINEERING FLIGHT TEST OF THE UH-1C HELICOPTER EQUIPPED WITH THE M-5 GRENADE LAUNCHER AND THE XM-158 OR XM-159 AIRBORNE ROCKET LAUNCHER PODS SUSPENDED FROM THE XM-156 MULTIARMAMENT MOUNT

Final Report By

JERRY W. PETRIE
PROJECT ENGINEER

GARY C. HALL
MAJOR, US ARMY, TC
PROJECT PILOT

February 1967

U. S. ARMY AVIATION TEST ACTIVITY
EDWARDS AIR FORCE BASE, CALIFORNIA

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ABSTRACT

Presented are the results of engineering flight test of the UH-1C (UH-1B/540 rotor) helicopter equipped with the M-5 grenade launcher and the XM-158 or XM-159 airborne rocket launcher pods suspended from the XM-156 multiarmament helicopter mount. Testing was conducted by U. S. Army Aviation Test Activity (USAAVNTA) at Edwards Air Force Base, Fort Irwin and Bakersfield, California. Eighty-five flights for a productive flight time of 48 hours were flown on UH-1B/540 rotor helicopter S/N 64-14105 between 1 August 1966 and 25 October 1966. Testing included 32 jettison flights for the XM-158 pods, 20 jettison flights for the XM-159 pods and 16 firings of the XM-159 pods.

The objective was to determine quantitative effect of the XM-159 pods installed from the XM-156 mount on the stability, control and performance of the helicopter; to determine the XM-158 and XM-159 pod jettison characteristics and define the flight envelope for safe jettison of the pods; and to determine the flight envelope for firing the XM-159 rocket launcher pods.

There were no significant adverse changes in the stability and control characteristics of the UH-1B/540 rotor helicopter due to the installation of the XM-159 pods. The previously reported longitudinal dynamic instability in climbs was also present throughout the tests.

The self-excited undamped lateral 2/3-per-rev vibration was prevalent during the tests. Due to the possible safety-of-flight implications this condition should be investigated and corrected if necessary.

Insufficient rocket-to-aircraft clearance for firing the XM-159 pods on the XM-156 mount was present without the addition of 4-inch cast aluminum spacers between the XM-156 mount and the universal pylon.

The XM-159 pods were adjusted to maximum elevation to provide sufficient clearance for firing with the spacers installed.

No major stability and control problems were encountered during the firing tests of the XM-159 or during the jettison tests of both the XM-158 and XM-159. Recommended flight envelopes were developed for jettison of both systems.

FOREWORD

The U. S. Army Test and Evaluation Command (USATECOM) assigned to the U. S. Army Aviation Test Activity (USAAVNTA) responsibility for preparing test plan, conducting test, and submitting final report.

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SECTION 1 INTRODUCTION

1.1 BACKGROUND

1.1.1 XM-158 Airborne Rocket Launcher Pods

The 7-round, 2.75-inch XM-157 (modified LAU 32A/A) airborne rocket launcher pods currently used with the XM-16 and XM-21 armament subsystems are considered by the U. S. Army Missile Command Redstone Arsenal, Redstone, Alabama, as failing to fully satisfy the unique requirements of the Army. Particularly, they are not reusable after exposure to hot humid environments. Since U. S. Navy and U. S. Air Force tactics are to jettison the pods after use, the pods need not be reusable. For U. S. Navy and U. S. Air Force use, however, the rocket tubes must be inclosed with a fairing to minimize drag. Fairings are not essential for use with present Army helicopters and the pods must be reusable. The 7-round, reusable, unfaired, 2.75-inch XM-158 airborne rocket launcher pods has therefore been developed specifically for Army use to replace the XM-157 airborne rocket launcher pods.

USATECOM issued a test directive to USAAVNTA on 4 August 1965 to conduct engineering tests to determine whether the jettison envelope with the XM-157 pods is applicable to the XM-158 pods. Additionally, stability and control tests were to be conducted as deemed necessary to determine whether information in the operator's manual should be supplemented.

The plan of test for engineering test of armament subsystems installed on the UH-1B/540 rotor helicopters, USATECOM Project No. 4-5-1591-01, was submitted by USAAVNTA in August 1965. USATECOM approved this test plan on 15 October 1965 as the basis for conducting the engineering test of the XM-158 rocket launcher pods.

A recommended jettison envelope for XM-158 airborne rocket launcher pods suspended from the XM-156 multiarmament helicopter mount on a UH-1B/540 rotor helicopter was submitted by USAAVNTA on 30 September 1966 (appendix V, paragraph i).

1.1.2 XM-159 Airborne Rocket Launcher Pods

To meet a need for additional armament subsystems with a large capacity of 2.75-inch folding-fin aerial rockets (FFAR's),

it was proposed to use two 19-round XM-159 airborne rocket launcher pods suspended from the XM-156 multiarmament helicopter mount on the UH-1B/540 rotor helicopter. USATECOM issued a test directive to USAAVNTA, on 30 March 1966, to conduct engineering test with respect to performance, stability and control, and handling characteristics of the UH-1B/540 rotor helicopter equipped with the XM-159 airborne rocket launcher pod. This included establishing a safe jettison flight envelope. USAAVNTA submitted a test plan dated June 1966 which was approved by USATECOM and forwarded to the U. S. Army Materiel Command on 19 August 1966. Shake tests were conducted by the airframe contractor and preliminary results were reviewed by USAAVNTA before the initiation of the engineering flight test.

A recommended safety-of-flight release for the 2.75-inch FFAR XM-159 airborne rocket launcher pod suspended from the XM-156 multiarmament helicopter mount on a UH-1B/540 rotor aircraft was submitted by USAAVNTA on 4 October 1966 (appendix V, paragraph v).

1.1.3 XM-156 Multiarmament Helicopter Mount

A suspension system of the XM-16 or XM-21 armament systems with the machine guns and rocket launchers removed is designated the XM-156 multiarmament helicopter mount. USATECOM amended the test directive to include an evaluation of the XM-156 multiarmament helicopter mount as well as the XM-159 airborne rocket launcher pods.

1.1.4 Engineering Flight Tests

The engineering flight test of the UH-1C (UH-1B/540 rotor) helicopter equipped with the XM-158 rocket launcher pods, XM-159 rocket launcher pods, and XM-156 multiarmament helicopter mount were conducted at test sites in Fort Irwin, Bakersfield, and Edwards Air Force Base, California. Testing was conducted from 1 August 1966 through 25 October 1966. Eighty-five flights totaling 48 productive flight hours were required to accomplish these tests. The chin turret mounted M-5 grenade launcher was installed throughout the test.

1.2 DESCRIPTION OF MATERIEL

1.2.1 UH-1B/540 Rotor Helicopter

The UH-1B/540 rotor helicopter is a utility helicopter powered by the T53-L-11, 1100-shaft horsepower gas turbine

engine. The rotor system is a two-bladed, teetering, semi-rigid rotor 44-feet in diameter with a 27-inch chord. The fuselage is identical to that of the standard UH-1B helicopter except for the addition of a UH-1D horizontal stabilizer and a cambered vertical stabilizer. A more detailed description of the UH-1B/540 rotor helicopter is contained in appendix III, paragraph 1.0.

PHOTO 3
UH-1B/540 equipped with XM-158/XM-16 and XM-21 armament subsystem

1.2.2 XM-158 Airborne Rocket Launcher Pods

The XM-158 airborne rocket launcher is a 7-round, reusable, 2.75-inch airborne rocket launcher pod. This launcher consists of 7 aluminum rocket tubes bound together by a stainless steel band over 2 sets of cast aluminum support segments. No external fairings are provided. Mounting lugs are attached to clamping bands and spaced 14 inches apart to accommodate mounting from the standard XM-16/XM-21 mounting system (XM-156). A more detailed description of the XM-158 rocket launcher pods is included in appendix III, paragraph 9.0.

PHOTO 4 - UH-1B/540 equipped with XM-159/M-5 armament system

1.2.3 XM-159 Airborne Rocket Launcher Pods

The XM-159 airborne rocket launcher pods are 19-round, reusable, 2.75-inch airborne rocket launcher pods. The pods consist of 19 aluminum rocket tubes encased in an aluminum fairing. The pods have mounting lugs spaced 14 inches apart to accommodate mounting from the XM-156 multiarmament helicopter mount. A more detailed description of the XM-159 airborne rocket launcher pods is included in appendix III, paragraph 10.0.

1.2.4 XM-156 Multiarmament Helicopter Mount

The XM-156 multiarmament helicopter mounting system is identical to the MA-4A bomb rack portion of the XM-16 or XM-21 armament subsystem except for the installation of a 19-round stepper switch. When used with the 19-round airborne XM-159 airborne rocket launcher pods the 7.62 machine guns and gun pylons are removed from the system to stay within weight limitations. The mount attaches to the universal stores

PHOTO 5 - UH-1B/540 equipped with XM-159/M-5 armament system

pylon, one installed on either side of the UH-1B or UH-1B/540 rotor helicopter. When the XM-159 airborne rocket launcher pods are used 4-inch cast aluminum spacers between the XM-156 multi-armament mount and the universal stores pylon are necessary to provide adequate rocket-to-skid-tube clearance during firing. The manual jettison cable must also be extended 4 inches when the 4-inch spacers are used. The XM-156 dual mount is capable of carrying and firing the 2.75-inch limited-spin folding-fin aerial rocket (LSFFAR) XM-157, XM-158, and XM-159 launcher pods. It is also capable of carrying stores limited to 505 pounds per side from its 14-inch spaced suspension hooks. A more detailed description of the XM-156 multiarmament helicopter mount is included in appendix III, paragraph 11.0.

1.2.5 XM-60 Sight

The pilot used the XM-60 sight during firing of the 2.75-inch rockets throughout the test of the XM-156/XM-159

armament subsystem. Detailed description of the XM-60 sight is included in appendix III, paragraph 11.0.

1.3 TEST OBJECTIVES

The overall objectives were:

a. To verify safety-of-flight of the XM-158 and XM-159 airborne rocket launcher pods attached to the XM-156 multiarmament mount installed on the UH-1B/540 rotor helicopter.

b. To develop subsystem data for inclusion in the operator's manual.

c. To assure that use of these armament subsystems does not impose limitations on the operational characteristics of the UH-1B/540 rotor helicopter.

The specific objectives were:

a. To determine quantitative effect of the XM-159 rocket launcher pods installed with the XM-156 multiarmament helicopter mount on the performance, stability and control of the helicopter.

b. To determine the XM-158 and XM-159 airborne rocket launcher pods jettison characteristics and establish a flight envelope for safe jettison of the pods.

c. To determine the flight envelope for firing the XM-159 rocket launcher pods.

1.4 SUMMARY OF RESULTS

The significant results of this test are summarized below:

a. An unsatisfactory self-excited, undamped lateral 2/3-per-rev vibration occurred under stabilized flight conditions. The effect of this vibration on component life could have a safety-of-flight implication.

b. The XM-156 multiarmament helicopter mount requires the installation of 4-inch cast aluminum spacers. The spacers should be placed between the XM-156 multiarmament mount and the universal stores pylon to provide adequate rocket-to-aircraft clearance for firing. The manual release jettison cables must be lengthened 4 inches for the system to operate with the spacers.

c. The XM-159 rocket launcher pods must be adjusted to maximum elevation (+6 degrees elevation relative to the helicopter waterline). This would provide adequate rocket-to-aircraft clearance for firing.

d. Caution should be exercised during firing while hovering in ground effect due to the pitchdown of the aircraft. Firings should be limited to seven pairs of rockets during this period.

e. When compared to the unarmed UH-1B/540 rotor helicopter (appendix V, paragraph bb), the installation of empty XM-159 airborne rocket launcher pods present a loss in specific range at 5000 ft density altitude of 7.3 percent (%) at 8000 lbs, 6.9% at 8500 lbs, and 4.4% at 9000 lbs.

f. At a forward center of gravity (C.G.) there was insufficient longitudinal control to hover downwind at wind velocities greater than 20 knots.

g. The helicopter is dynamically unstable in high powered climbing flight in the speed range for maximum rate of climb (45 to 60 knots calibrated airspeed [KCAS]).

h. Sensitivity of the firing contacts on the XM-159 airborne rocket launcher pods to vibrations, moisture and detent lock wear caused a high rocket malfunction rate.

i. Jack screws for sway pads provided with the XM-159 airborne rocket launcher pods were too short to accommodate the XM-158 airborne rocket launcher pods.

j. The XM-156 multiarmament helicopter mount Preliminary Operating and Maintenance Manual (POMM 1090-204-14) is in error relative to XM-159 airborne rocket launcher pod firing orders.

1.5 Conclusions

No unusual characteristics were encountered with the UH-1B/540 rotor helicopter equipped with the XM-158 rocket launcher pods suspended from the XM-156 multiarmament helicopter mount except for the following:

a. An unsatisfactory self-excited, undamped lateral 2/3-per-rev vibration occurs under stabilized flight conditions (paragraph 2.3.5).

b. Four-inch cast aluminum spacers must be installed between the XM-156 multiarmament mount and the universal stores pylon (paragraph 2.4.1) for sufficient rocket-to-aircraft clearance during firing.

c. The XM-159 rocket launcher pods must be adjusted at maximum elevation (+6 degrees elevation relative to helicopter waterline) to provide adequate rocket-to-aircraft clearance for firing (paragraph 2.4.1).

d. Sensitivity of the firing contacts on the XM-159 rocket launcher pods to vibrations, moisture, and detent lock wear caused a high rocket malfunction rate (paragraph 2.4.1).

e. It is necessary to exercise caution during firing while hovering in ground effect due to the pitchdown of the aircraft. Firings should be limited to seven pairs of rockets during this period (paragraph 2.4.1).

f. Inadequate control margin exists at a forward C.G. during downwind hovering (paragraph 2.3.1).

g. There is a longitudinal dynamic instability during high powered climbs (paragraph 2.3.3).

h. Jack screws for sway pads provided with XM-159 rocket launcher pods were too short to accommodate the XM-158 rocket launcher pods (paragraph 2.6).

i. The POMM 1090-204-14 for the XM-156 multiarmament mount was in error regarding the firing order of the XM-159 rocket launcher pods (paragraph 2.6).

j. Level flight performance data from this report should be incorporated in operator's manual (paragraph 2.2.1).

1.6 Recommendations

a. The cause of self-excited undamped 2/3-per-rev vibration should be investigated by the contractor immediately and corrective actions and/or modifications evaluated (paragraph 2.3.5).

b. XM-159 rocket launcher pods should not be issued for service test or field use without the 4-inch cast aluminum spacers and lengthened manual jettison cables as part of the kit (paragraph 2.4.1).

c. Specific instructions should accompany the XM-159 rocket launcher kits stating that the launcher be adjusted to maximum elevation for firing purposes (+6 degrees eleation relative to the helicopter waterline) (paragraph 2.4.1).

d. The operator's manual should include a warning which states, "Caution should be exercised during firing while hovering (in ground effect) due to pitchdown of the aircraft. Firing should be limited to seven pairs of rockets." (paragraph 2.4.1)

e. Due to inadequate control margin, the operator's manual should include a warning that states: "Downwind approaches should be avoided and hovering downwind should not be attempted at wind speeds above 20 knots," (paragraph 2.3.1).

f. The longitudinal dynamic instability present during high powered climbs should be noted in the operator's manual. Further investigation should be made to determine the best possible performance climb speed which alleviates this characteristic (paragraph 2.3.3).

g. The firing contacts and locking detents should be improved to reduce the rocket malfunction rate (paragraph 2.4.1).

h. Jack screws for the sway pads that will be common to all rocket launcher pods should be provided in the XM-156 multiarmament mount kits (paragraph 2.6).

i. POMM 1090-204-14 for the XM-156 multiarmament mount should be corrected to reflect the proper firing order of the XM-159 rocket launcher pods (paragraph 2.6).

j. Level flight performance data from this report should be included in the UH-1B/540 rotor helicopter operator's manual (paragraph 2.2.1).

SECTION 2 DETAILS OF TEST

2.1 INTRODUCTION

This report presents the results of an engineering flight test of the UH-1B/540 rotor helicopter equipped with the M-5 grenade launcher and the XM-158 or XM-159 airborne rocket launcher pods suspended from the XM-156 multiarmament helicopter mount.

The objective of the flight tests was:

a. To determine the quantitative effect of the XM-159 rocket launcher pods installed with the XM-156 multiarmament mount on the performance, stability and control of the helicopter.

b. To determine the XM-158 and XM-159 rocket launcher pod jettison characteristics.

c. To define the flight envelope for safe jettison of the pods.

d. To determine the flight envelope for firing the XM-159 rocket launcher pods.

e. To determine the flight envelope for firing the XM-159 rocket launcher pods.

The 7-round XM-158 rocket launcher pods will be used in conjunction with the XM-16 and XM-21 armament subsystems.

The XM-159 armament subsystem consists of a 19-round 2.75-inch FFAR launcher suspended from the XM-156 multiarmament helicopter mount. Machine guns and gun pylons are removed from the system to stay within weight limitations of the XM-156 multiarmament mount.

Details of test methods and data reduction procedures may be found in appendix II. A brief description of test methods are included for clarification of the individual test.

2.2 PERFORMANCE

Quantitative performance testing was conducted with the XM-159 airborne rocket launcher pods installed. All performance tests were conducted with empty XM-159 rocket launcher pods and a full load of M-5, 40-mm grenade launcher ammunition. This resulted in the greatest decrease in performance due to the

increased drag produced by the forward C.G. of the aircraft. The similarity of the XM-158 airborne rocket launcher pods and installation to the XM-157 (LAU 32A/A) pods previously tested (appendix V, paragraph cc), precluded the necessity for performance testing (appendix V, paragraph e).

2.2.1 Level Flight Performance

The objective of the performance test was to determine the change in helicopter performance due to the XM-159 multi-armament subsystem configuration. Level flight performance tests of the XM-159/M-5 armament subsystem were conducted to cover a range of selected thrust coefficients (C_T). This allowed a comparison with the level flight performance of the clean UH-1B/540 rotor helicopter and other configured armed UH-1B/540 rotor helicopters. A constant C_T was maintained by climbing to a new test altitude as fuel was used (appendix II, paragraph 1.2). The flight conditions for the 7-speed power polars conducted to determine level flight performance were conducted at gross weights from 7375 lbs to 8620 lbs, density altitudes from 3530 ft to 11,190 ft, and a rotor speed of 325 revolutions per minute (rpm). Test results are presented in figures 4 through 10, appendix I. Nondimensional summary plots are presented in figures 2 and 3, appendix I. Specific range for each speed power polar presented was calculated based on specification fuel flow, (figure 33, appendix I). A plot of actual test aircraft referred fuel flow versus referred shaft horsepower is presented in figure 32, Appendix I.

Level flight range summaries are presented in figure 1, appendix I. All range summary calculations are based on the non-dimensional level flight performance summary (figures 2 and 3, appendix I), and specification fuel flow (figure 33, appendix I). A comparison is made with the unarmed UH-1B/540 rotor (mid C.G.), XM-21/M-5 (fwd C.G.), and the XM-3/M-5 (fwd C.G.) armament subsystems. Presentation of the data at the above C.G.'s is based on normal operating conditions and loadings. When compared with the unarmed UH-1B/540 rotor, the XM-159/M-5 multiarmament subsystem presents a loss in specific range at 5000 ft density altitude of 7.6% at 8000 lbs, 6.6% at 8500 lbs, and 5.5% at 9000 lbs. The optimum cruise airspeed varies from 105 KTAS at 7100 lbs to 99 KTAS at 9500 lbs. Normal armed mission weight will vary between 7100 lbs and 8650 lbs without passengers or cargo as shown in appendix III, paragraph 10.1).

Level flight tests were conducted at an average C.G. of 126 inches (fwd). C.G. limits are fuselage station 125 max fwd

and station 134 max aft. This forward C.G. is due to the moment produced by the M-5 armament subsystem. Tail ballast may be used to allow greater freedom in loading and operation. Figure 37, appendix I, presents the envelope for tail ballast installed at fuselage station 425. This is a straight line extrapolation from zero lbs to 6600 lbs gross weight to 50 lbs at 7275 lbs gross weight and above (appendix V, paragraph z).

2.2.2 Airspeed Calibration

The objective of this test was to determine the airspeed position error for both the standard and test boom airspeed systems. The calibrated trailing bomb method was used from 29 to 106 KCAS. A T-28B aircraft with a ground course calibrated airspeed system was used for airspeed calibration points at the higher airspeeds (88 to 131 KCAS). The pacer aircraft method was employed. The test results for the ship system are presented graphically in figure 30, appendix I.

The standard airspeed system met the requirements of MIL-I-6115A (appendix V, paragraph ee), between 33 and 130 KCAS. Below 33 KCAS the standard system maximum error was 6 KCAS. The system is considered satisfactory.

The standard airspeed system compared favorably with the calibration presented in the "Operator's Manual, Army Models UH-1A and UH-1B Helicopter," (appendix V, paragraph x). From 30 to 116 KCAS the airspeed variation was less than or equal to 1 KCAS. The operator's manual airspeed calibration showed an increasing variation over the test ship of 1 to 3.5 KCAS over the 116 to 130 KCAS range.

2.3 STABILITY AND CONTROL

Quantitative stability and control tests were conducted with the XM-159 airborne rocket launcher pods installed. The similarity of the XM-158 airborne rocket launcher pods to the XM-157 (LAU 32A/A) pods previously tested (appendix V, paragraph cc) precluded the necessity for stability and control testing (appendix V, paragraph e). Qualitative observations confirmed that no significant difference exists in the stability and control characteristics of the helicopter with either the XM-157 or XM-158 airborne rocket launcher pods installed.

2.3.1 Static Longitudinal Stability (XM-159)

The objective of this test was to determine the static longitudinal control position with respect to airspeed. Static

longitudinal stability was investigated using two methods (appendix II, paragraph 1.3.1). The first method consisted of recording the control positions in trimmed level flight at various airspeeds. The data for this test was collected during level flight performance tests. It is presented graphically in figures 11 through 16, appendix I. Longitudinal control position stability was positive for all conditions tested except for the normal helicopter longitudinal cyclic stick reversal below 35 KCAS. No significant difference between the apparent degree of static longitudinal stability of the unarmed UH-1B/540 rotor helicopter (appendix V, paragraph bb), and the UH-1B/540 rotor helicopter with the XM-159 airborne rocket launcher pods installed was indicated. Comparison was made between the slopes of the control position versus airspeed curves. The longitudinal stick position stability characteristics meet the requirements of MIL-H-8501A (appendix V, paragraph y).

No rearward flight tests were conducted. However, the same lack of sufficient control margin when hovering downwind at forward C.G. locations found in previous tests was experienced (appendix V, paragraph cc). This characteristic is undesirable and should be investigated further to determine if the aircraft should be placarded. Hovering downwind should not be attempted at wind velocities above 20 knots.

The second method used to investigate static longitudinal stability was the collective fixed static longitudinal speed stability test. One flight was conducted for this test at an average gross weight of 8720 lbs. Average C.G. of 126.8 inches and 4900 ft average density altitude conditions were used. Test results are presented in figure 17, appendix I.

Collective fixed static longitudinal speed stability was positive about each trim point tested except above 120 KCAS. At this point stability approaches neutral and required very little forward cyclic stick to increase airspeed. Maximum airspeed limits therefore could inadvertently be exceeded. This characteristic while not unsatisfactory could be improved to prevent exceeding limit airspeed (V_{ne}) inadvertently. This characteristic does not meet the requirements of MIL-H-8501A. The normal instability below 35 KCAS was encountered and is considered satisfactory. Comparison of this data with the unarmed UH-1B/540 rotor helicopter indicates that no significant difference exists in static longitudinal speed stability characteristics (appendix V, paragraph bb).

2.3.2 Static Lateral-Directional Stability (XM-159)

The objective of this test was to evaluate the lateral-directional flying qualities, dihedral effects, and directional stability for a representative flight condition.

Static lateral-directional stability was investigated by measuring flight control positions during constant-heading, steady-state sideslips at various trim airspeeds (appendix II, paragraph 1.3.1). One flight was conducted at an average gross weight of 8710 lbs, average C.G. location of 126.8 inches (fwd) and 4390 ft average density altitude. Test results for trim airspeeds of 83.5, 104, 121 KCAS are presented in figures 18, 19, and 20 respectively in appendix I.

Static directional stability was determined to be positive from the directional control position gradients with sideslip angle about the trim point. Directional stability becomes slightly non-linear in right sideslip at 121 KCAS but is not considered unsatisfactory. Sideslips were conducted to the limits of the sideslip envelope or full directional pedal travel. The apparent degree of directional stability was not significantly different than for the unarmed UH-1B/540 rotor helicopter (appendix V, paragraph bb).

Dihedral effects were approximately neutral at 83.5 KCAS. It became increasingly negative as airspeed was increased. This characteristic was determined from the lateral control position gradients with sideslip angle about the trim points. This characteristic has been noted to varying degrees in all configurations of the UH-1B/540 rotor helicopter. This condition does not meet the requirements of MIL-H-8051A but was not considered objectionable to the pilot.

2.3.3 Dynamic Stability (XM-159)

The objective of this test was to determine the short period damping characteristics of the aircraft with the armament subsystem installed.

The limited dynamic stability characteristics obtained were determined from analysis of the time histories of the helicopter motions. Results were taken from pulse-type control inputs about all axes (appendix II, paragraph 1.3.2). These tests were conducted at maximum level flight airspeed (V_H) under the conditions listed in table I.

TABLE I

Average Density Altitude ft	Average Gross Weight lb	Average Center of Gravity Location in	Airspeed V_H KCAS
5000	8330	126.4	106
5000	7615	126.5	108

Time histories are presented in figures 24 through 26, appendix I. Time histories analysis indicated no significant difference in the dynamic stability characteristics from those of the unarmed UH-1B/540 rotor helicopter. Tests were also conducted in the climb instability region found in earlier tests (appendix V, paragraph cc). A longitudinal pulse during climbing flight in the speed range of 45 to 60 KCAS resulted in a slow divergent pitch oscillation. Constant monitoring of the pitch attitude was required to prevent a loss in altitude due to a longitudinal disturbance. This characteristic is common to all UH-1 series aircraft in various degrees. Further investigation should be made to determine the best possible performance climb speed which would alleviate this characteristic.

2.3.4 Controllability (XM-159)

The objective of this test was to determine the changes in helicopter sensitivity and response caused by installation of the XM-159 rocket launcher pods.

Controllability characteristics, control response (angular rate) and sensitivity (angular acceleration) were determined by analysis of the time histories. The time histories indicated helicopter motions resulting from step type control inputs about all axes (appendix II, paragraph 1.3.3). Limited tests were conducted at maximum level flight airspeed (V_H) under the same conditions listed for dynamic stability tests (paragraph 2.3.3). The test data is presented in figures 21 through 23, appendix I.

Controllability tests were conducted at gross weight of 7615 and 8330 lb. The difference of 715 lb in the gross weight of the two tests presented showed that no significant difference in controllability, in this weight range, resulted from weight variation under normal loading operation. Analysis of the data also indicated that no significant difference exists between the controllability characteristics of the test aircraft and the unarmed UH-1B/540 rotor helicopter.

2.3.5 Vibrations

The vibration characteristics of the test helicopter were recorded throughout the test program at various flight conditions. There was no noticeable level flight vibration level increase over that of the Phase B unarmed UH-1B/540 rotor helicopter test program (appendix V, paragraph aa). The self-excited, undamped pylon motion occuring at a frequency of 2/3-per-rev discovered in previous tests (appendix V, paragraph bb), was still prevalent. This condition could have safety-of-flight implications and should be corrected immediately.

2.4 FIRING

Firing tests were conducted utilizing the XM-159 airborne rocket launcher pods only.

2.4.1 Firing Tests of the XM-159 Airborne Rocket Launcher Pods

The objective of the firing tests was to determine the effects on the stability and control characteristics of the UH-1B/540 rotor helicopter caused by firing the XM-159 airborne rocket launcher pods. Also, to insure that no unsafe conditions resulted from these firings throughout the flight envelope. The reactions of the helicopter to rocket firing were recorded on an oscillograph and by air-to-air photographic coverage from a chase aircraft. Rocket-to-aircraft clearance was recorded by high speed motion picture cameras strategically located on the skid tubes and above the rocket launcher. The method employed during the firing tests is described in detail in appendix II, paragraph 1.5.

Initial firings prior to bore sighting showed that 2 1/2 inches of clearance existed between the rocket fin and the toe of the skid tube. Bore sighting for parallel rocket sheaths moved the rocket trajectory inboard 3 inches. The test was suspended until the airframe contractor provided 4-inch cast aluminum spacers for installation between the universal stores pylon and the rack and support assembly. This modification also required lengthening the manual jettison cable 4 inches. The addition of the spacers increased the clearance between the rocket fins and the helicopter skid tube during firing to approximately 6 inches which was considered acceptable. In order to obtain this 6-inch clearance the XM-159 airborne rocket launcher pods must be installed at maximum elevation (+6 degrees elevation relative to the helicopter waterline). Firing at less elevation could result in a safety hazard due to a clearance reduction.

A variable rate intervalometer was installed in the test helicopter to allow a build up to the maximum firing rate of 6 rounds per second. This is the standard rate for all systems in the field.

All firings were conducted with scarfed nozzle rocket. Sixteen firing tests were conducted expending a total of 513 rockets at the conditions shown in table II. These conditions are presented as the recommended firing envelope. Firing while hovering in ground effect should be limited to seven pairs of rockets. Caution should be exercised during this period due to the pitchdown of the aircraft which could result in the rockets striking the ground in close proximity to the aircraft.

TABLE II

Flight Condition	KCAS Airspeed Range
Level flight	35 to 100
Maximum Power Descent	100 to 124 (V_{NE})
Autorotation	70 to 100
Hovering In Ground Effect (IGE) (Limit to seven pairs of rockets)	0

Only 7 rocket pairs could be fired in a ripple with one depression of the firing button due to the design of the electrical system. However, even when all 38 airborne rocket launcher pods were fired by pressing the button 3 times in rapid succession without recovering only mild pitchdown of the helicopter occurred. The pitchdown was less than the XM-3, 48-round rocket launcher previously tested (appendix V, paragraph cc). This pitchdown was easily corrected by the pilot. No undesirable characteristics were noted during the firing tests.

Thirty-one of the 513 airborne rocket launcher pods loaded malfunctioned. This high failure rate (6%) is believed to be caused by the difficulty in (1) adjusting the firing contact, (2) open contact due to inflight vibrations and (3) rapid wear of the detent lock. During inclement weather considerable static electricity was present in the rocket launcher pods resulting in

unsafe arming conditions. Accumulation of moisture in the rocket launcher pods during cleaning could cause shorts in the firing mechanism.

2.5 JETTISON

The criteria used to limit the jettison flight envelope was pod aerodynamic instability or unacceptable skid tube damage from pod strikes on the skid tubes after jettison.

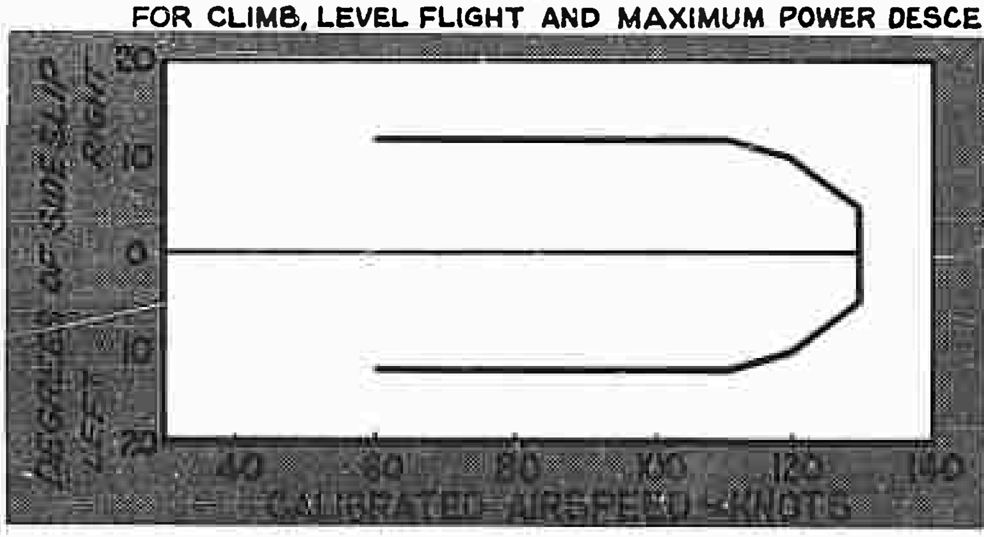
2.5.1 Jettison Test of XM-158 Airborne Rocket Launcher Pods

The objective of the jettison tests of the XM-158 airborne rocket launcher pods was to determine a safe jettison flight envelope. It was determined from results of previous tests of the XM-157 (modified LAU-32A/A) pods that jettison with empty pods was more critical than with loaded pods. For this reason only empty pods were jettisoned. Thirty-two inflight jettisons of empty pods were conducted. The jettison envelope developed is based on the analysis of photographic coverage obtained. High speed motion picture cameras mounted on the skid tube looking aft and the tail boom looking fwd were used. Air-to-air photographic coverage was also obtained and analyzed.

The pod hit the aft portion of the skid tubes resulting in superficial paint damage during all jettisons above 80 KCAS.

Figure A RECOMMENDED UH-IC XM-158 JETTISON ENVELOPE

FOR CLIMB, LEVEL FLIGHT AND MAXIMUM POWER DESCENT



The method employed during the jettison tests is described in detail in appendix II, paragraph 1.4. The test results of 32 jettisons showed that safe jettison could be accomplished in climb, level flight and maximum power descents up to and including 130 KCAS. Jettison testing was performed within the recommended sideslip limits as shown in figure A. Actual test points are presented in figure No. 28, appendix I. Safe jettison could also be accomplished in autorotations and partial power descents at zero sideslip up to and including 95 KCAS. A photo sequence of a jettison is shown in figure B. Conditions for the jettison are shown below:

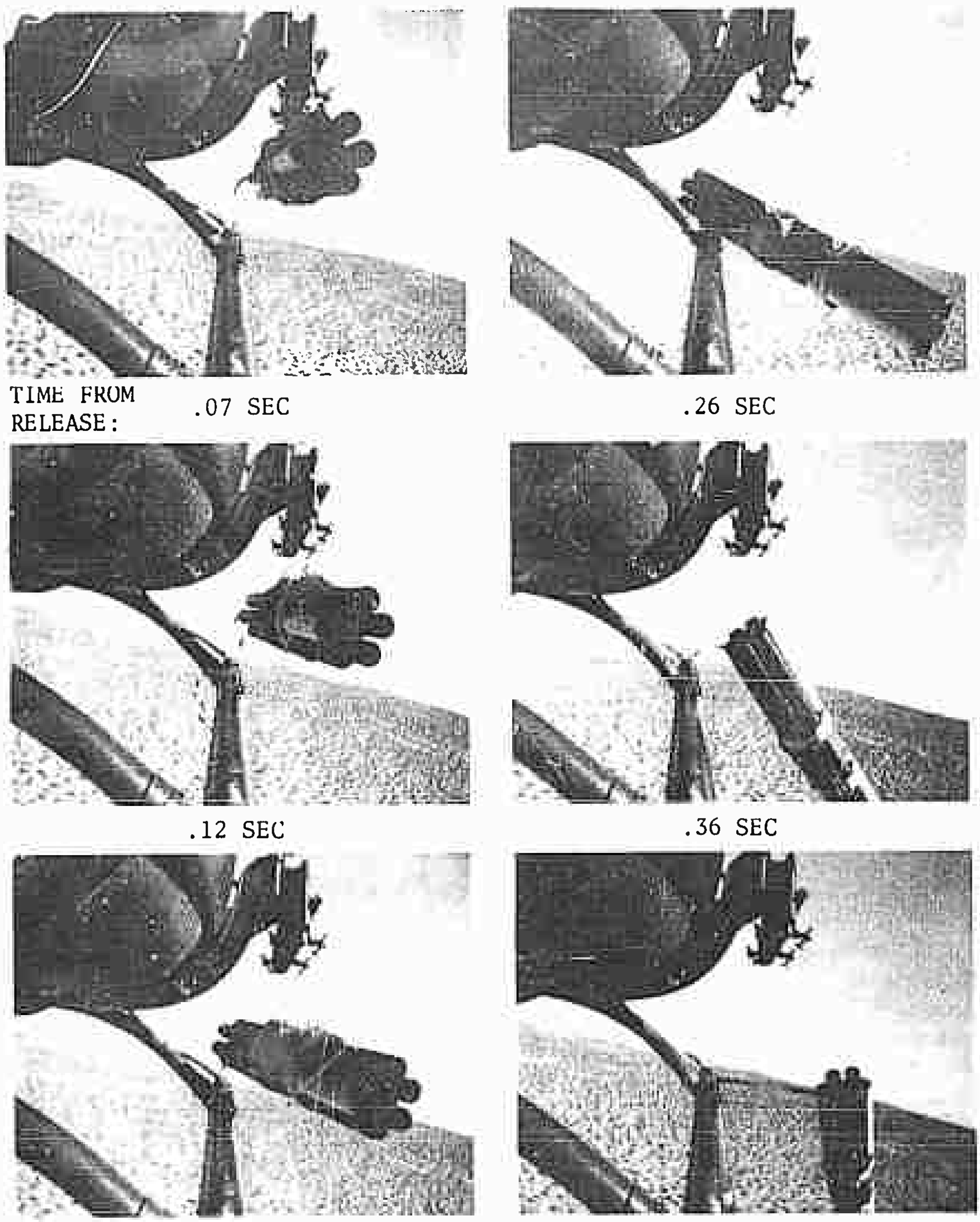
Calibrated Airspeed kts	Angle of Sideslip deg	Bank Angle deg	C.G. Location in	Gross Weight lb	Angle of Attack deg
126	11° Right	10° Right	129	7500	6° Down

2.5.2 Jettison Test of XM-159 Airborne Rocket Launcher Pods

The objective of the jettison test of the XM-159 airborne rocket launcher pods (pods) was to determine and recommend a safe jettison flight envelope. Empty pods were used for most of the jettisons since empty pods are most critical to aerodynamic forces after jettison. Spot checks were made with full pods to determine the damage caused to the skid tubes when struck by full pods. The pods struck the skid tubes when jettisoned in all flight regimes. Only superficial skid tube damage was sustained in all cases, both with full and empty pods. The jettison envelope was therefore established using primarily pod aerodynamic instability after jettison as the criteria. The jettison envelope developed is based on the analysis of optical coverage. This optical coverage was obtained by using high speed motion picture cameras mounted on the fwd section of the skid tube looking aft and on the tail boom looking fwd. Air-to-air photographic coverage was also obtained and analyzed. Jettison tests were conducted before and after the addition of 4-inch cast aluminum spacers between the XM-156 multiarmament helicopter mount and the universal stores pylon. Analysis of this comparative data reveals that the spacers did not appear to effect the jettison characteristics.

The method employed during the jettison tests is described in detail in appendix II, paragraph 1.4. Level flight jettison data indicated the critical flight conditions to be jettisons

Figure B XM-158 JETTISON



1 TIME FROM RELEASE: .07 SEC

2 .12 SEC

3 .18 SEC

4 .26 SEC

5 .36 SEC

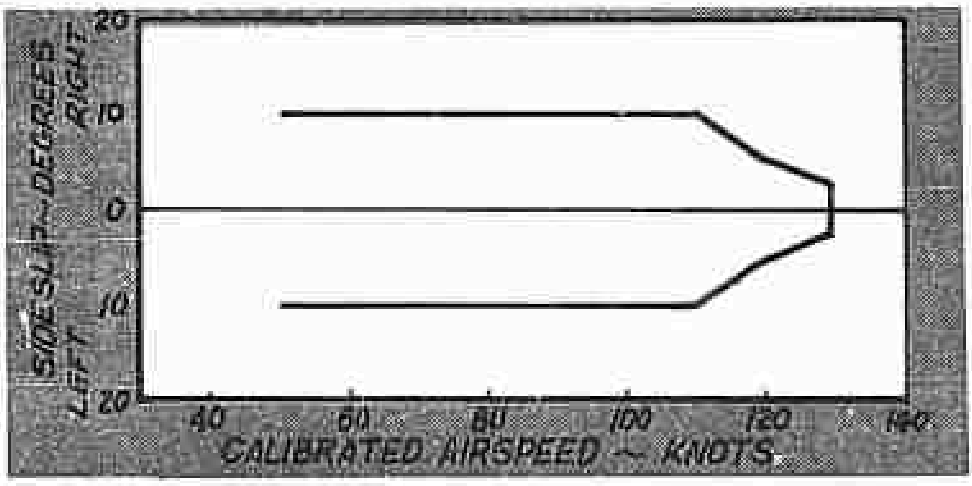
6 .41 SEC

from the high side (left side in right sideslip and right side in left sideslip) due to increasing roll attitude with increasing sideslip. The pods had a tendency to yaw after jettison. The envelope was closed when this yaw became unpredictable as to aerodynamic instability.

The test results of 20 jettisons indicated that safe jettison of the pods could be accomplished in climbs, level flight and maximum power descent up to and including 130 KCAS within the recommended sideslip envelope shown in figure C. Test points are shown in figure 29, appendix I. Safe jettison could also be accomplished in autorotations and partial power descents at zero sideslip up to and including 95 KCAS.

Figure C RECOMMENDED UH-1C XM-159 JETTISON ENVELOPE

FOR CLIMB, LEVEL FLIGHT AND MAX.POWER DESCENT

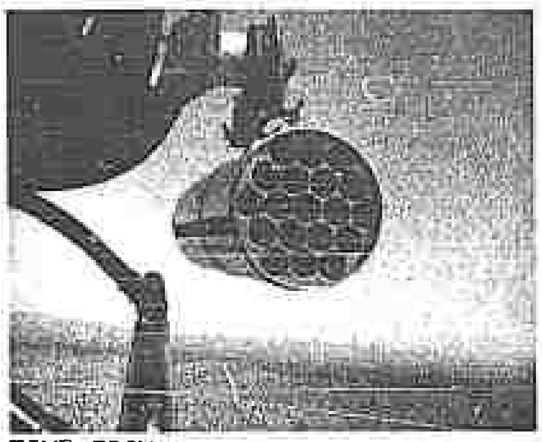


No malfunctions of the electrical jettison system were experienced. It is recommended that the skid assembly mounting points be checked for damage after all jettisons. A photo sequence of a limiting jettison is shown in figure D. Conditions for the jettison are shown below:

Calibrated Airspeed kts	Angle of Sideslip deg	Bank Angle deg	C.G. Location in	Gross Weight lb	Angle of Attack deg
131.5	5° Right	3.5° Right	129	7640	7° Down

Figure D XM-159 JETTISON

1



TIME FROM RELEASE: .03 SEC

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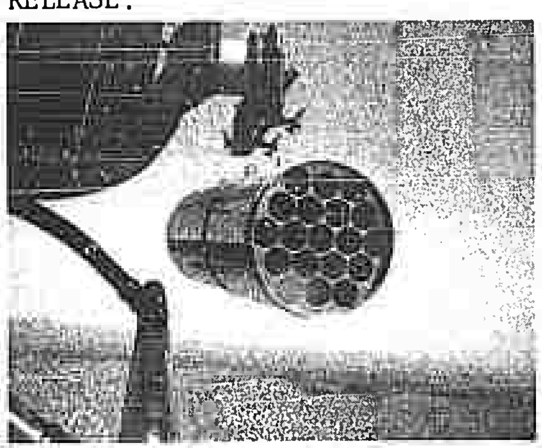

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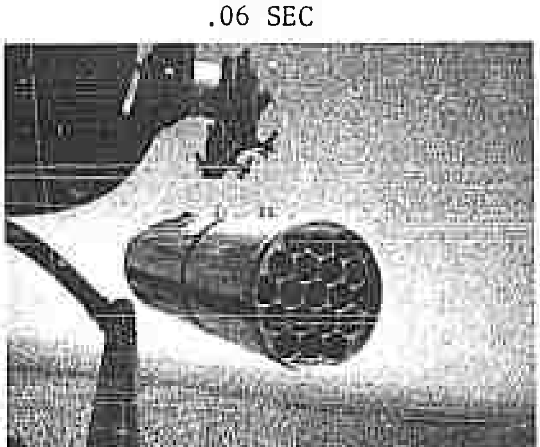
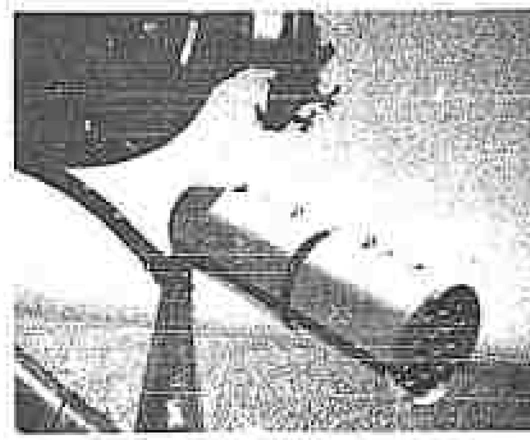
3



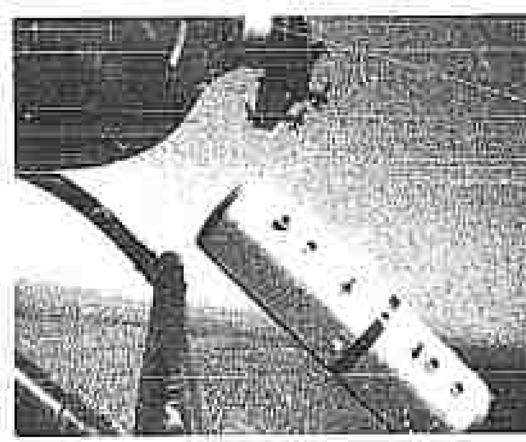
.11 SEC

4



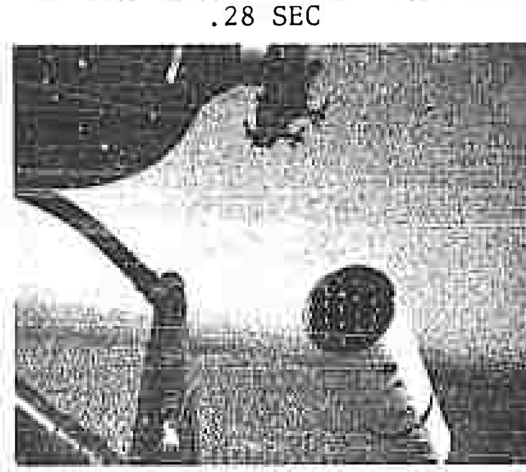
.19 SEC

5



.28 SEC

6



.38 SEC

2.6 XM-156 MULTIARMAMENT HELICOPTER MOUNT

The XM-156 multiarmament helicopter mount was evaluated throughout the test program. The most significant deficiency of the mount is the requirement of 4-inch cast aluminum spacers to provide adequate rocket-to-aircraft clearance. This characteristic was discussed in detail in paragraph 2.5.2.

The jack screws on the sway pads received with the XM-156 multiarmament helicopter mount were too short to allow substitution of the XM-158, 7-round airborne rocket launcher pods on the XM-156 multiarmament helicopter mount in place of the XM-159 airborne rocket launcher pods. Sway pads 3 1/8 inches in length from a XM-16/XM-21 mount used in a previous test were substituted and were usable for both the XM-158 and XM-159 airborne rocket launcher pods.

POMM 1090-204-14 for the XM-156 multiarmament helicopter mount was found to be in error. Section 4-3 covering the preloading voltage test is erroneous due to the firing order given in the manual. The XM-159 airborne rocket launcher pod has a different firing order for each side. Neither matches the manual's firing order.

SECTION 3
APPENDIX I

FIGURE NO. 1
LEVEL FLIGHT RANGE SUMMARY
UH-1B/540 T53-L-11 ENGINE
5000 FT STANDARD DAY
324 ROTOR RPM

SYM	ARMAMENT SUBSYSTEM
○	CLEAN UH-1B/540 (MID C.G.) (REFERENCE bb)
□	XM-159/M-5 (FWD C.G.)
△	XM-21/M-5 (FWD C.G.) (REFERENCE cc)
◁	XM-3/M-5 (FWD C.G.) (REFERENCE cc)

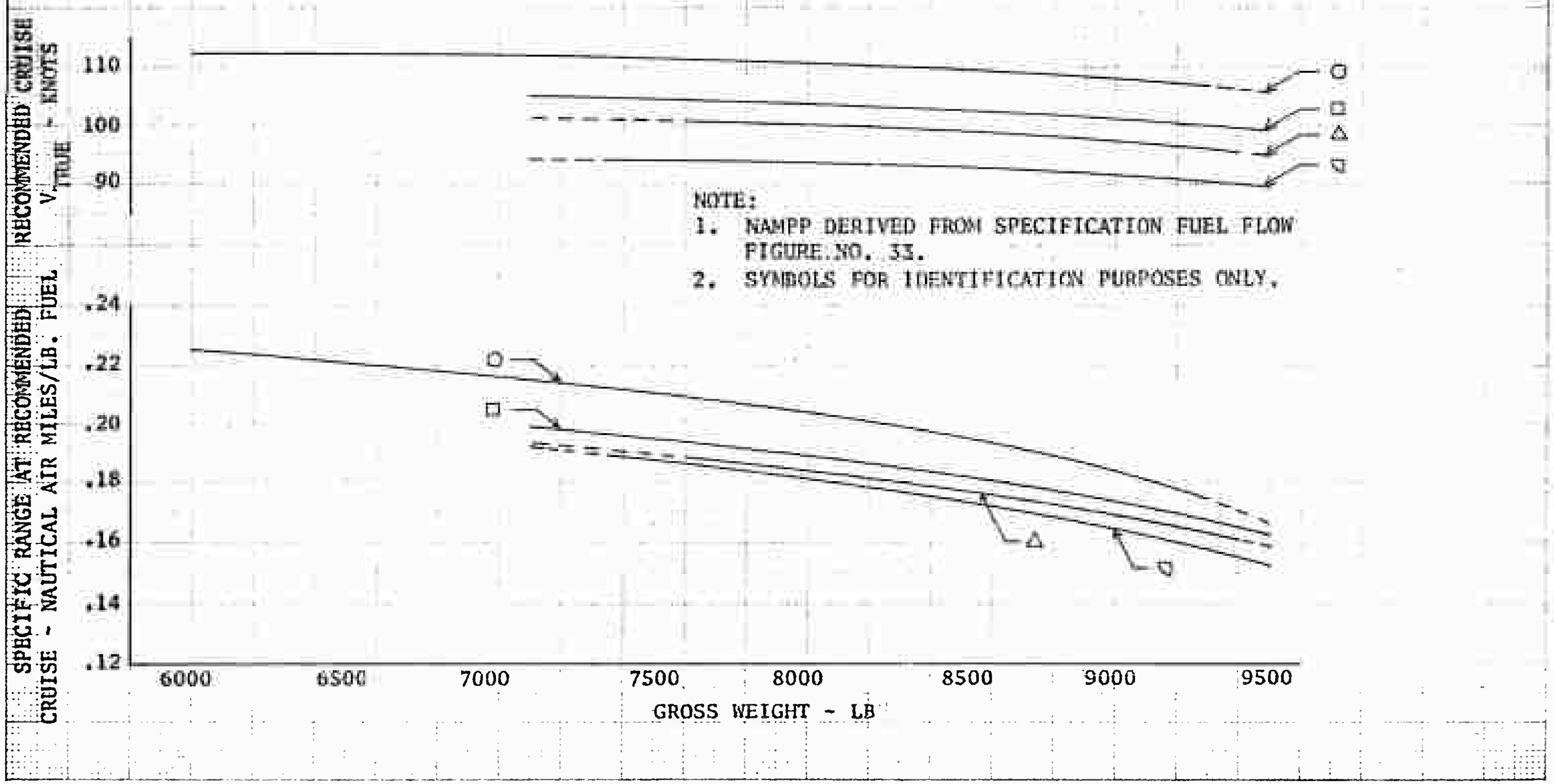


FIGURE NO. 2
NON-DIMENSIONAL LEVEL FLIGHT PERFORMANCE SUMMARY
UH-1B/540 USA S/N 64-14105
T53-L-11 ENGINE
XM-159/M-5 ARMAMENT SUBSYSTEM
AVERAGE C.G. = 126 (FWD)
EMPTY PODS

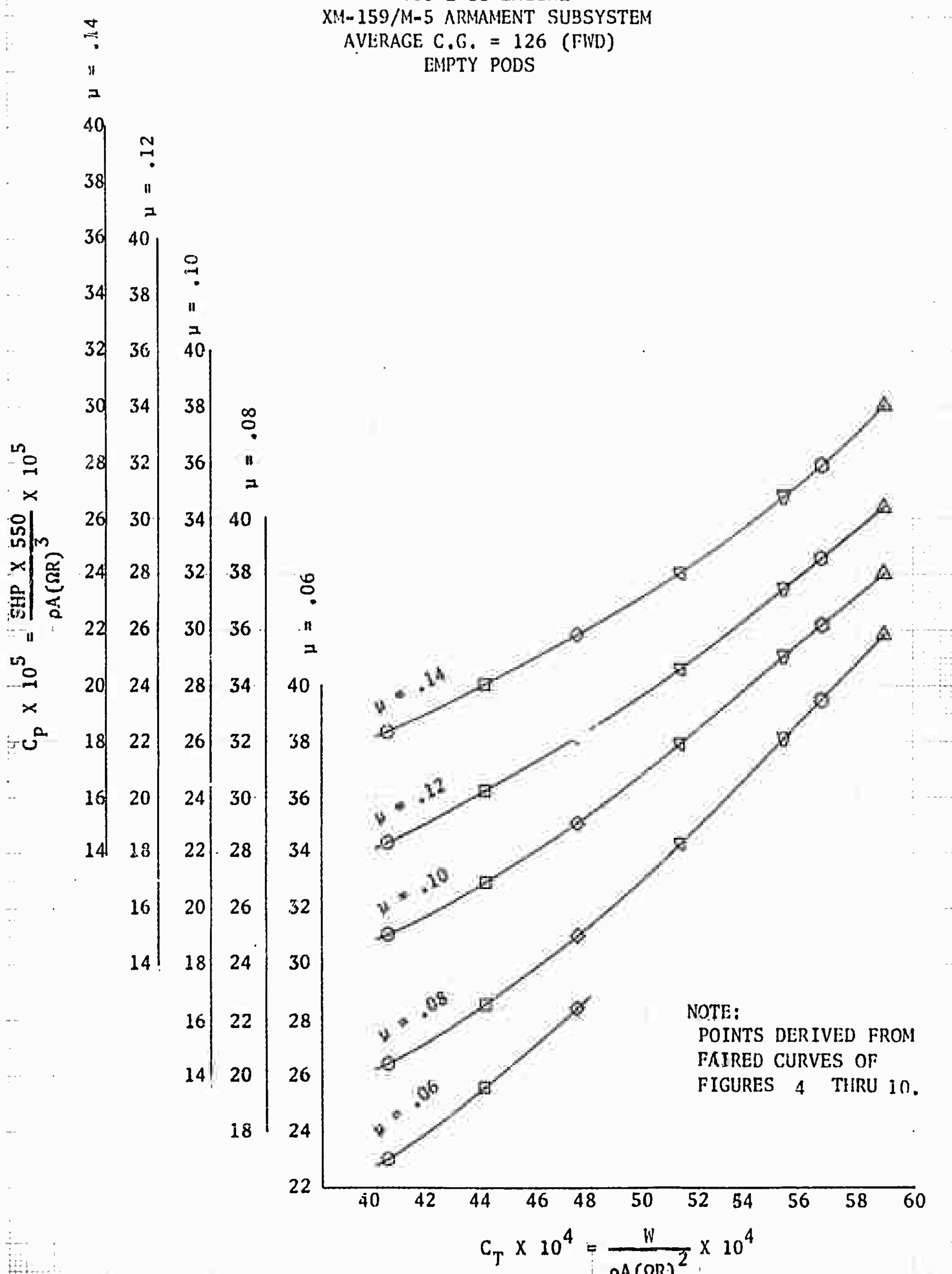
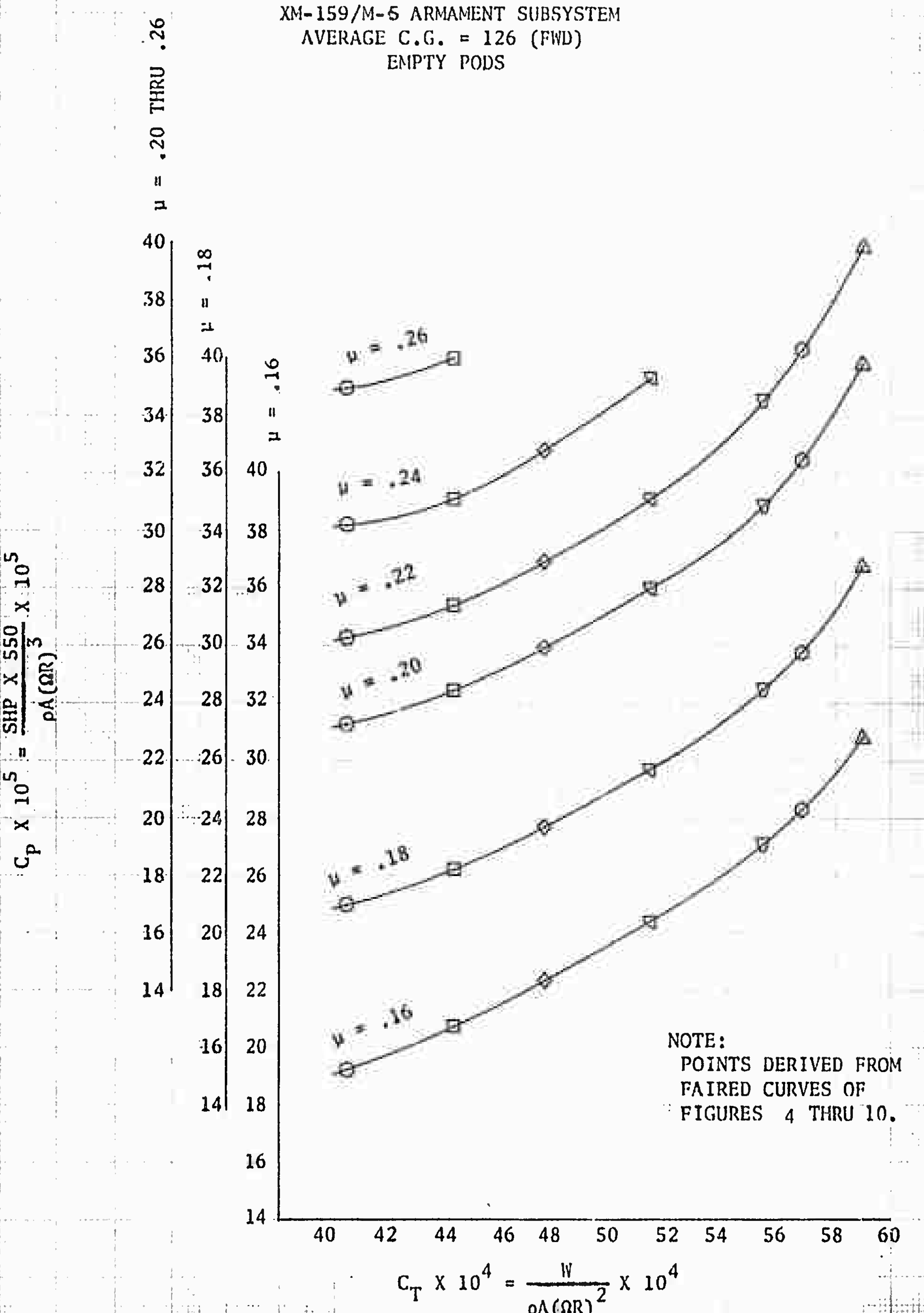


FIGURE NO. 3
NON-DIMENSIONAL LEVEL FLIGHT PERFORMANCE SUMMARY
UH-1B/540 USA S/N 64-14105
T53-L-11 ENGINE
XM-159/M-5 ARMAMENT SUBSYSTEM
AVERAGE C.G. = 126 (FWD)
EMPTY PODS



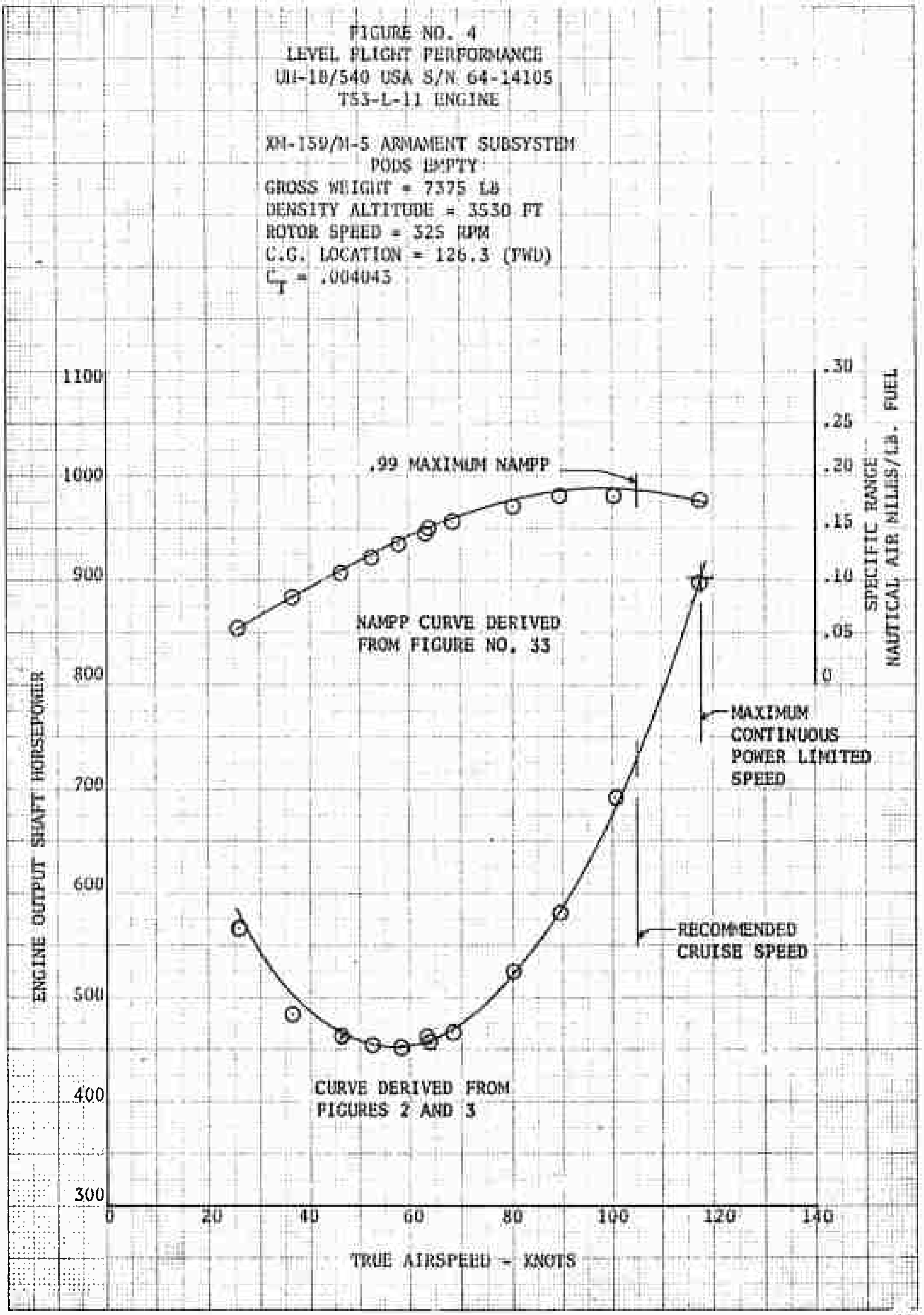


FIGURE NO. 4
LEVEL FLIGHT PERFORMANCE
UH-1B/540 USA S/N 64-14105
T53-L-11 ENGINE
XM-159/M-5 ARMAMENT SUBSYSTEM
PODS EMPTY
GROSS WEIGHT = 7375 LB
DENSITY ALTITUDE = 3530 FT
ROTOR SPEED = 325 RPM
C.G. LOCATION = 126.3 (FWD)
C_T = .004043
.99 MAXIMUM NAMPP
NAMPP CURVE DERIVED FROM FIGURE NO. 33
MAXIMUM CONTINUOUS POWER LIMITED SPEED
RECOMMENDED CRUISE SPEED
CURVE DERIVED FROM FIGURES 2 AND 3
ENGINE OUTPUT SHAFT HORSEPOWER
1100
1000
900
800
700
600
500
400
300
SPECIFIC RANGE NAUTICAL AIR MILES/LB. FUEL
.30
.25
.20
.15
.10
.05
0
0
20
40
60
80
100
120
140
TRUE AIRSPEED - KNOTS

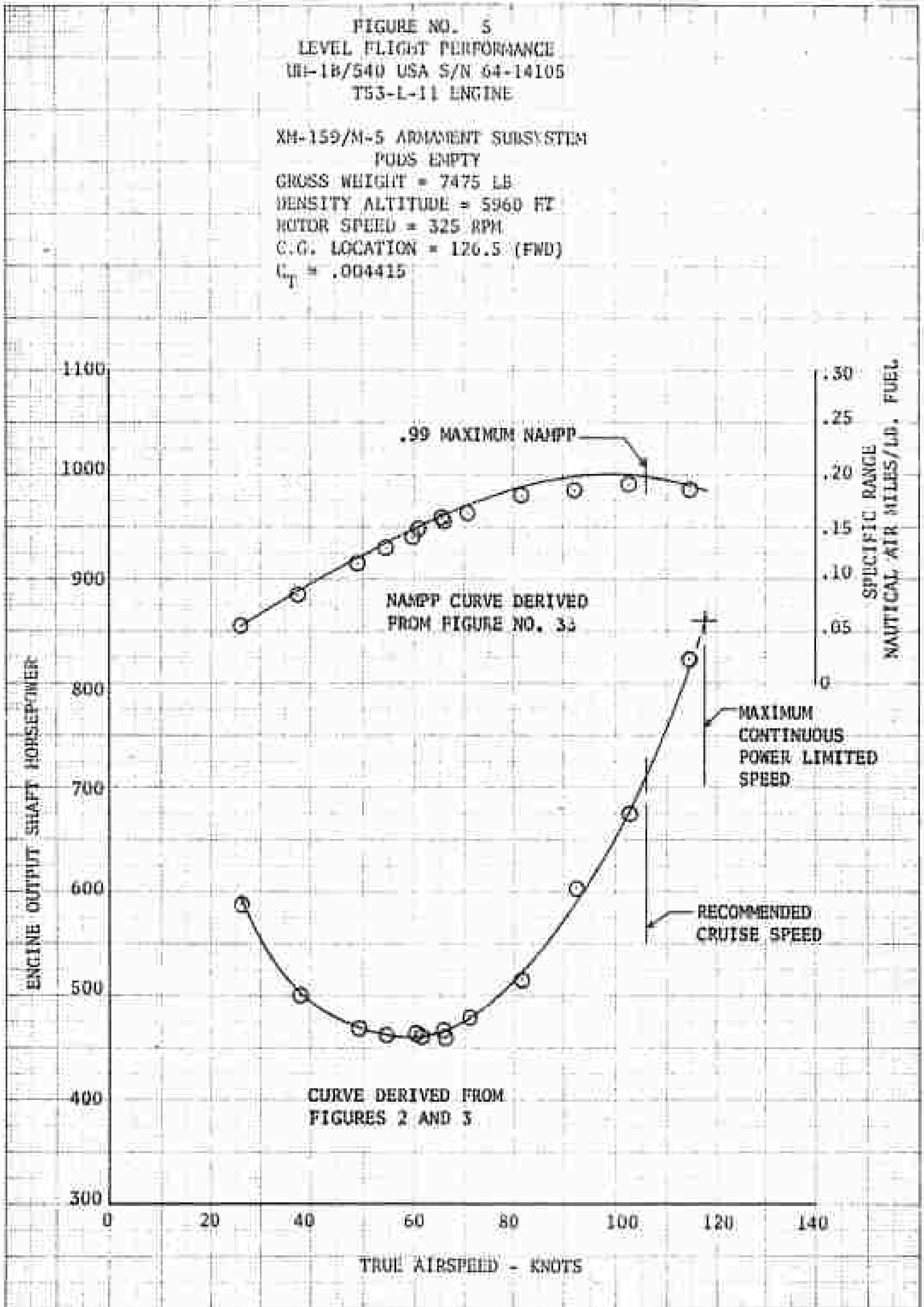


FIGURE NO. 5
LEVEL FLIGHT PERFORMANCE
UH-1B/540 USA S/N 64-14105
T53-L-11 ENGINE
XM-159/M-5 ARMAMENT SUBSYSTEM
PODS EMPTY
GROSS WEIGHT = 7475 LB
DENSITY ALTITUDE = 5960 FT
ROTOR SPEED = 325 RPM
C.G. LOCATION = 126.5 (FWD)
C_T = .004415
.99 MAXIMUM NAMPP
NAMPP CURVE DERIVED
FROM FIGURE NO. 33
MAXIMUM
CONTINUOUS
POWER LIMITED
SPEED
RECOMMENDED
CRUISE SPEED
CURVE DERIVED FROM
FIGURES 2 AND 3
ENGINE OUTPUT SHAFT HORSEPOWER
SPECIFIC RANGE
NAUTICAL AIR MILES/LB. FUEL
TRUE AIRSPEED - KNOTS
1100
1000
900
800
700
600
500
400
300
.30
.25
.20
.15
.10
.05
0
0
20
40
60
80
100
120
140

FIGURE NO. 6
LEVEL FLIGHT PERFORMANCE
UH-1B/540 USA S/N 64-14105
T53-L-11 ENGINE

XM-159/M-5 ARMAMENT SUBSYSTEM
PODS EMPTY
GROSS WEIGHT = 8065 LB
DENSITY ALTITUDE = 5930. FT
ROTOR SPEED = 325 RPM
C.G. LOCATION = 126.2 (FM)
C_T = .004753

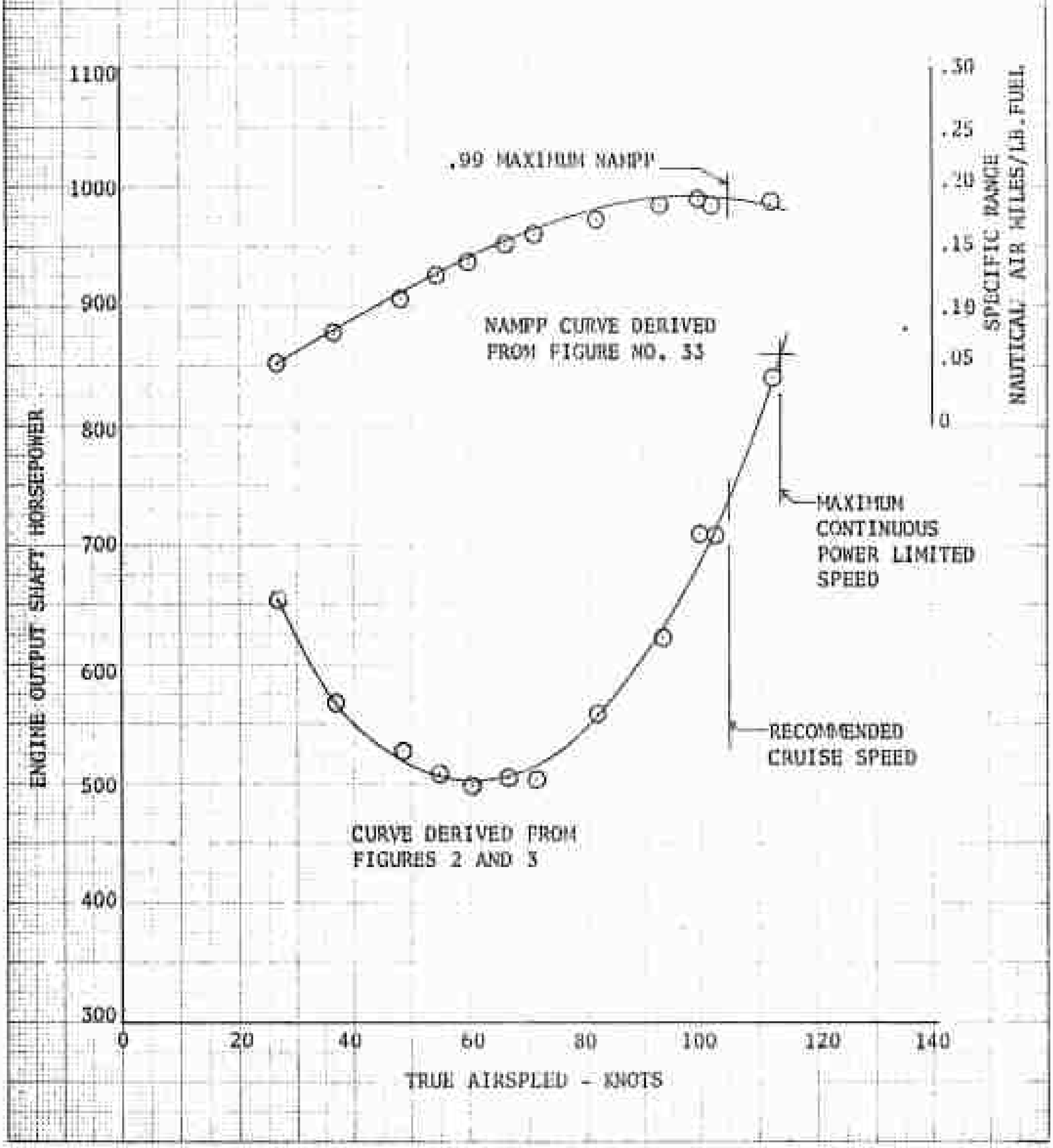
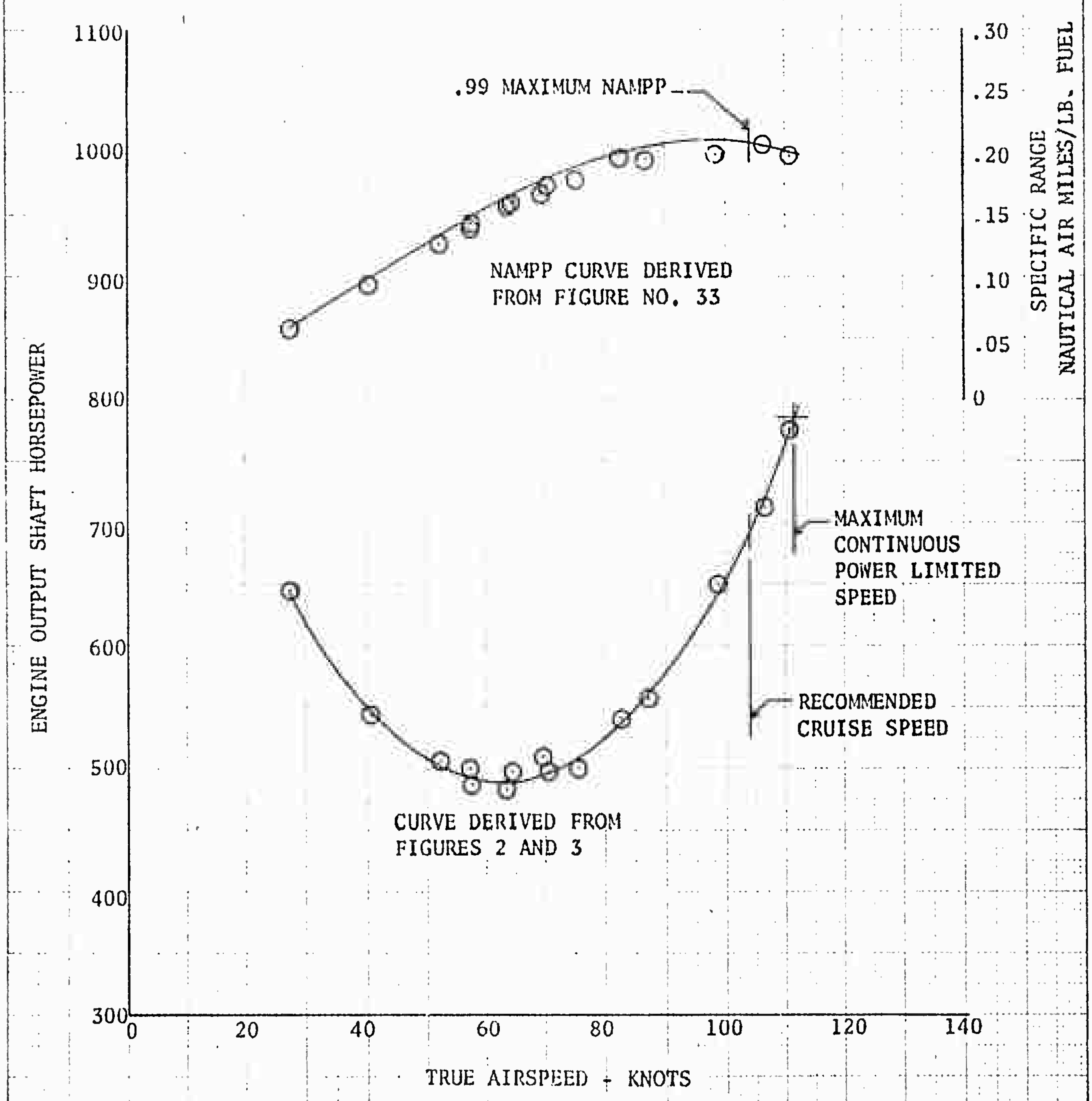


FIGURE NO. 7
LEVEL FLIGHT PERFORMANCE
UH-1B/540 USA S/N 64-14105
T53-L-11 ENGINE

XM-159/M-5 ARMAMENT SUBSYSTEM
PODS EMPTY
GROSS WEIGHT = 7680 LB
DENSITY ALTITUDE = 10,000 FT
ROTOR SPEED = 325 RPM
C.G. LOCATION = 125.9 (FWD)
C_T = .005136



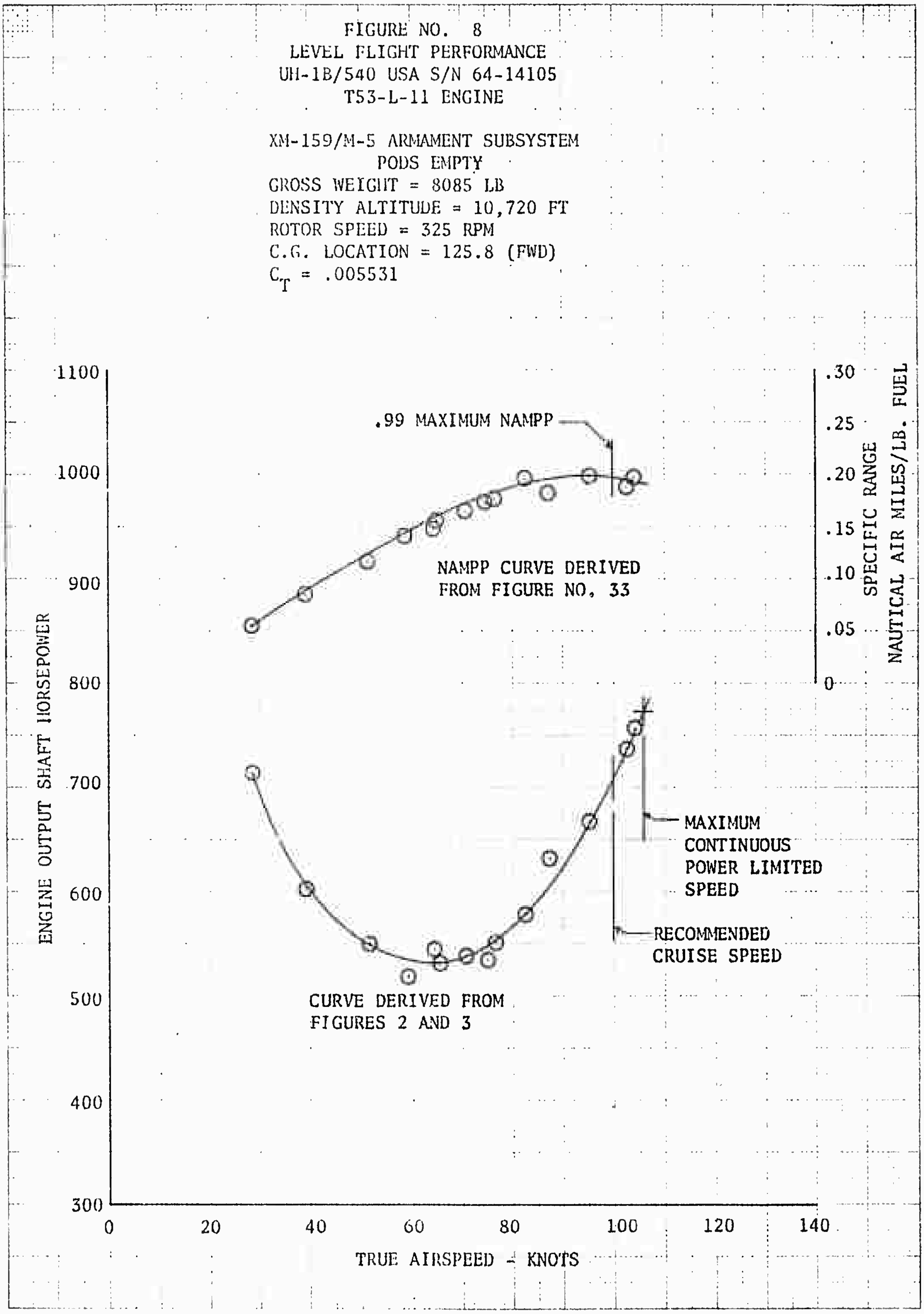


FIGURE NO. 8
LEVEL FLIGHT PERFORMANCE
UH-1B/540 USA S/N 64-14105
T53-L-11 ENGINE
XM-159/M-5 ARMAMENT SUBSYSTEM
PODS EMPTY
GROSS WEIGHT = 8085 LB
DENSITY ALTITUDE = 10,720 FT
ROTOR SPEED = 325 RPM
C.G. LOCATION = 125.8 (FWD)
C_T = .005531
.99 MAXIMUM NAMPP
NAMPP CURVE DERIVED FROM FIGURE NO. 33
MAXIMUM CONTINUOUS POWER LIMITED SPEED
RECOMMENDED CRUISE SPEED
CURVE DERIVED FROM FIGURES 2 AND 3
ENGINE OUTPUT SHAFT HORSEPOWER
1100
1000
900
800
700
600
500
400
300
SPECIFIC RANGE
NAUTICAL AIR MILES/LB. FUEL
.30
.25
.20
.15
.10
.05
0
0
20
40
60
80
100
120
140
TRUE AIRSPEED - KNOTS

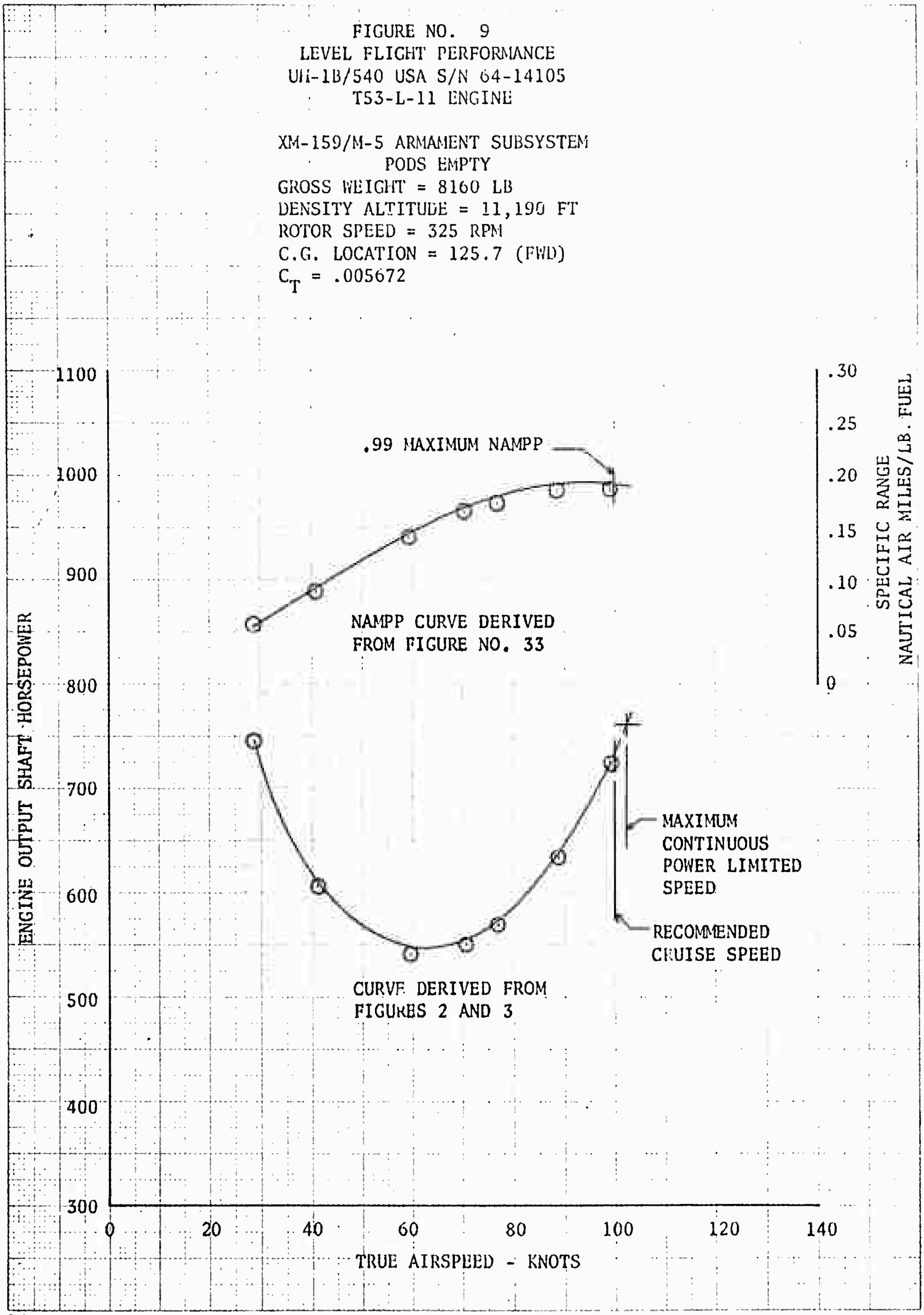


FIGURE NO. 9
LEVEL FLIGHT PERFORMANCE
UH-1B/540 USA S/N 64-14105
T53-L-11 ENGINE
XM-159/M-5 ARMAMENT SUBSYSTEM
PODS EMPTY
GROSS WEIGHT = 8160 LB
DENSITY ALTITUDE = 11,190 FT
ROTOR SPEED = 325 RPM
C.G. LOCATION = 125.7 (FWD)
C_T = .005672
.99 MAXIMUM NAMPP
NAMPP CURVE DERIVED FROM FIGURE NO. 33
MAXIMUM CONTINUOUS POWER LIMITED SPEED
RECOMMENDED CRUISE SPEED
CURVE DERIVED FROM FIGURES 2 AND 3
ENGINE OUTPUT SHAFT HORSEPOWER
SPECIFIC RANGE
NAUTICAL AIR MILES/LB. FUEL
TRUE AIRSPEED - KNOTS
1100
1000
900
800
700
600
500
400
300
.30
.25
.20
.15
.10
.05
0
0
20
40
60
80
100
120
140

FIGURE NO. 10
LEVEL FLIGHT PERFORMANCE
UH-1B/540 USA S/N 64-14105
T53-L-11 ENGINE

XM-159/M-5 ARMAMENT SUBSYSTEM
PODS EMPTY
GROSS WEIGHT = 8620 LB
DENSITY ALTITUDE = 10,480 FT
ROTOR SPEED =324 RPM
C.G. LOCATION = 126.7 (FWD)
C_T = .005896

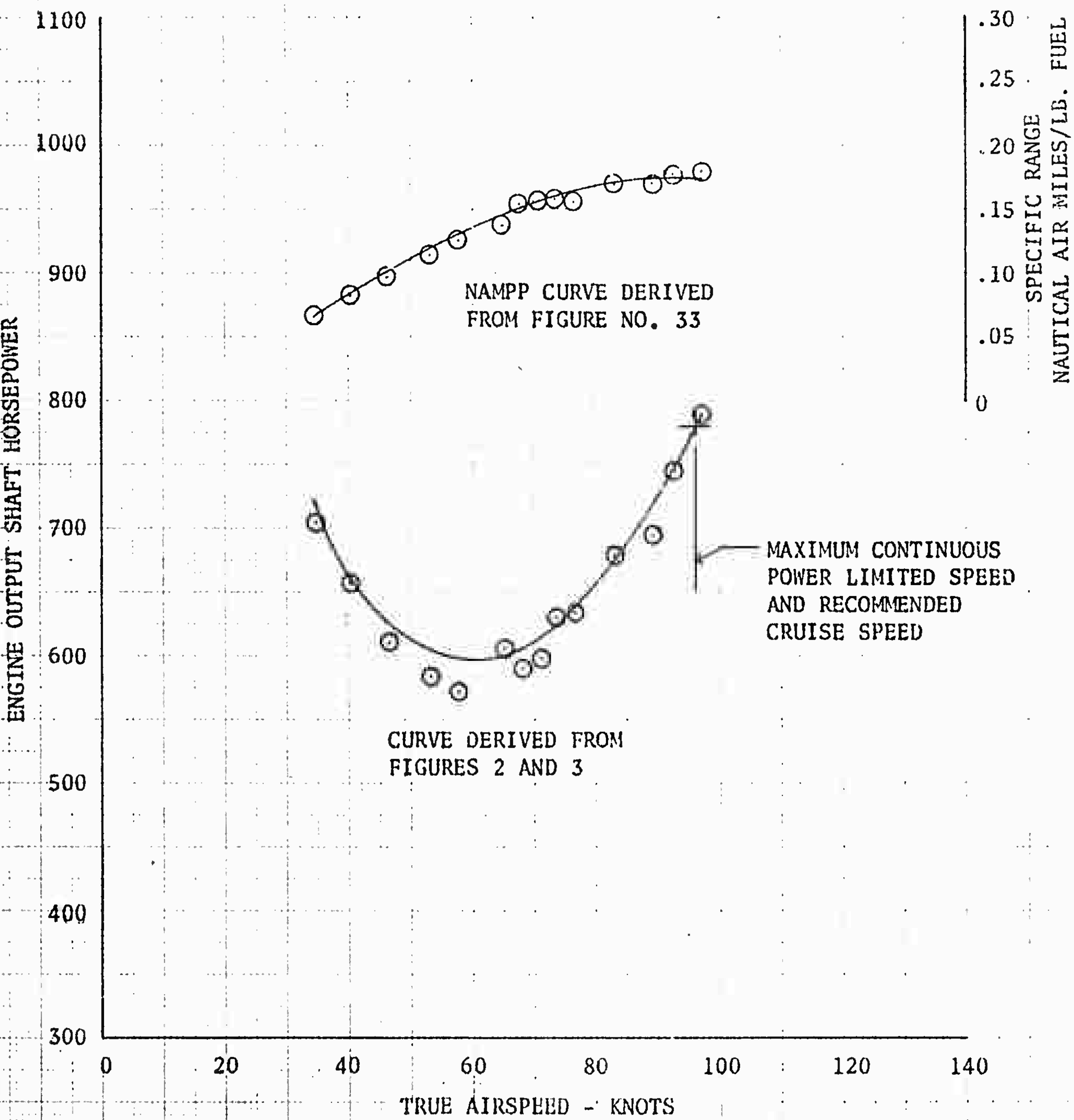


FIGURE NO. 11
CONTROL POSITIONS IN LEVEL FLIGHT
UH-1B/540 USA S/N 64-14105
XM-158/M-5 ARMAMENT SUBSYSTEM
PODS EMPTY

AVERAGE GROSS WEIGHT = 7370 LB
AVERAGE DENSITY ALTITUDE = 3530 FT
C.G. LOCATION = 126.3 IN
ROTOR SPEED = 325 RPM

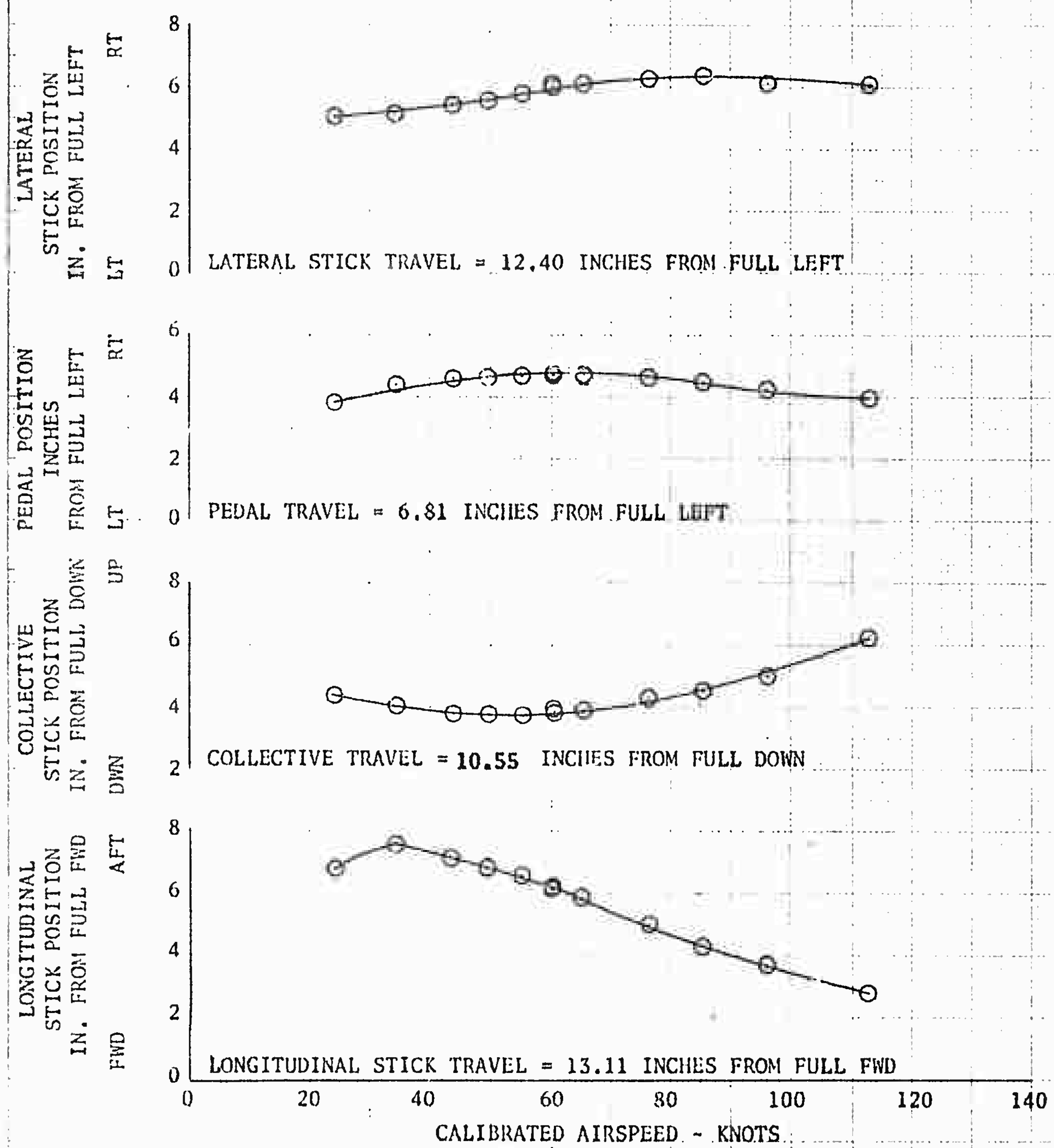


FIGURE NO. 12
CONTROL POSITIONS IN LEVEL FLIGHT
UH-1B/540 USA S/N 64-14105
XM-158/M-5 ARMAMENT SUBSYSTEM
PODS EMPTY
AVERAGE GROSS WEIGHT = 7475 LB
AVERAGE DENSITY ALTITUDE = 5960 FT
C.G. LOCATION = 126.5 IN
ROTOR SPEED = 325 RPM

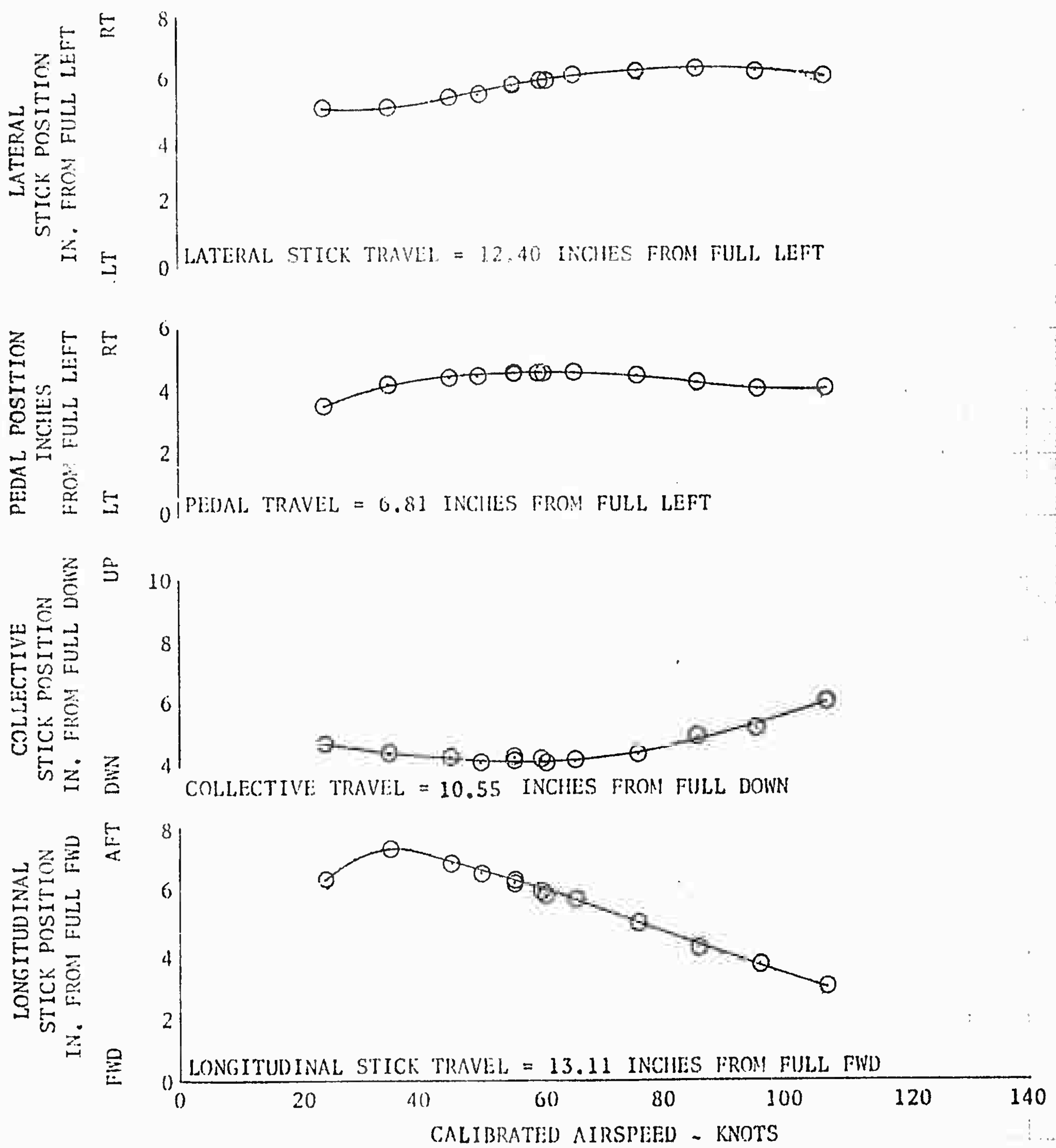


FIGURE NO. 13
CONTROL POSITIONS IN LEVEL FLIGHT
UH-1B/540 USA S/N 64-14105
XM-159/M-5 ARMAMENT SUBSYSTEM
PODS EMPTY
AVERAGE GROSS WEIGHT = 7680 LB
AVERAGE DENSITY ALTITUDE = 10,000 FT
C.G. LOCATION = 125.9 IN
ROTOR SPEED = 325 RPM

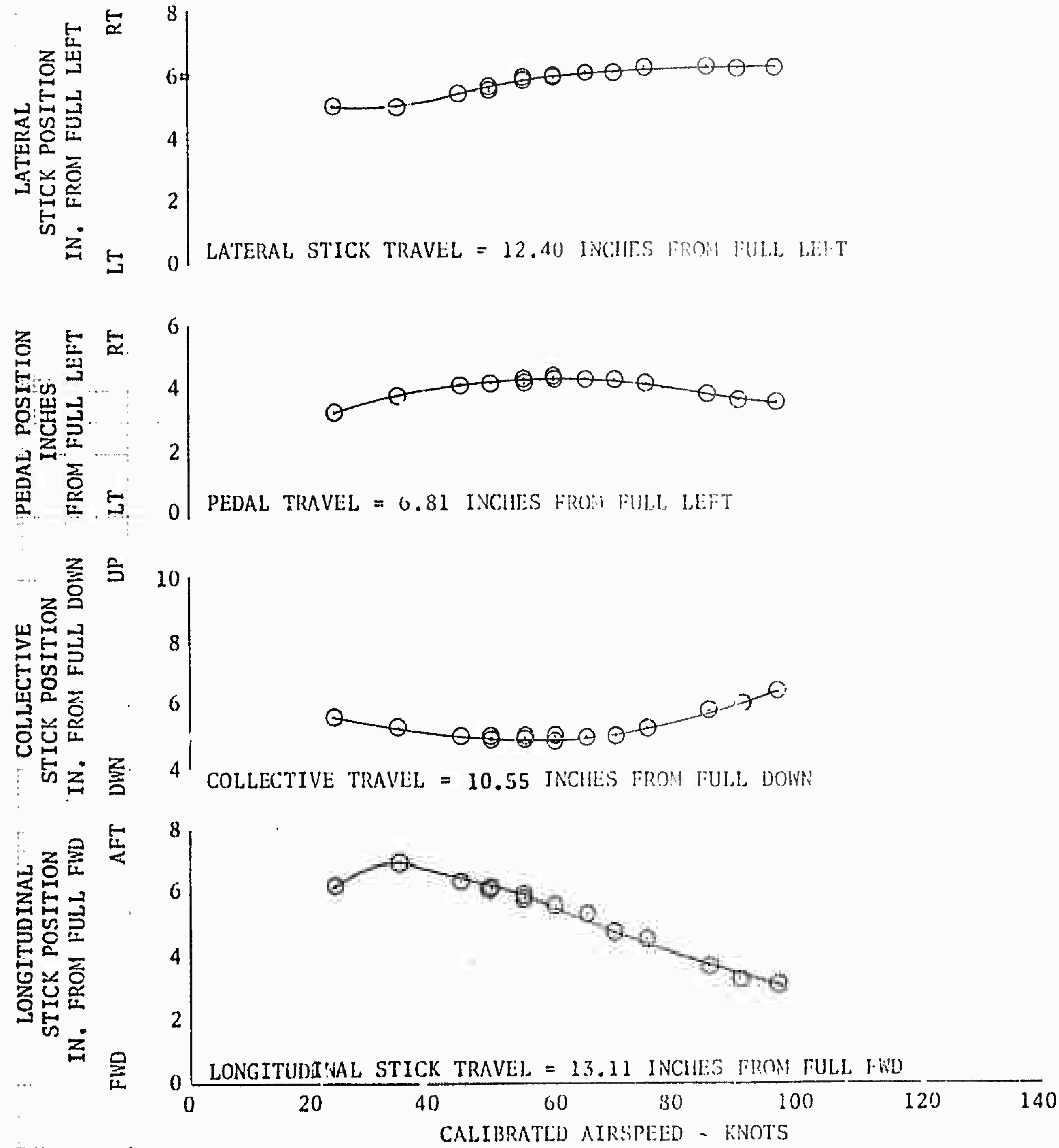


FIGURE NO. 14
CONTROL POSITIONS IN LEVEL FLIGHT
UH-1B/540 USA S/N 64-14105
XM-159/M-5 ARMAMENT SUBSYSTEM
PODS EMPTY
AVERAGE GROSS WEIGHT = 8065 LB
AVERAGE DENSITY ALTITUDE = 5950 FT
C.G. LOCATION = 126.2 IN
ROTOR SPEED = 325 RPM

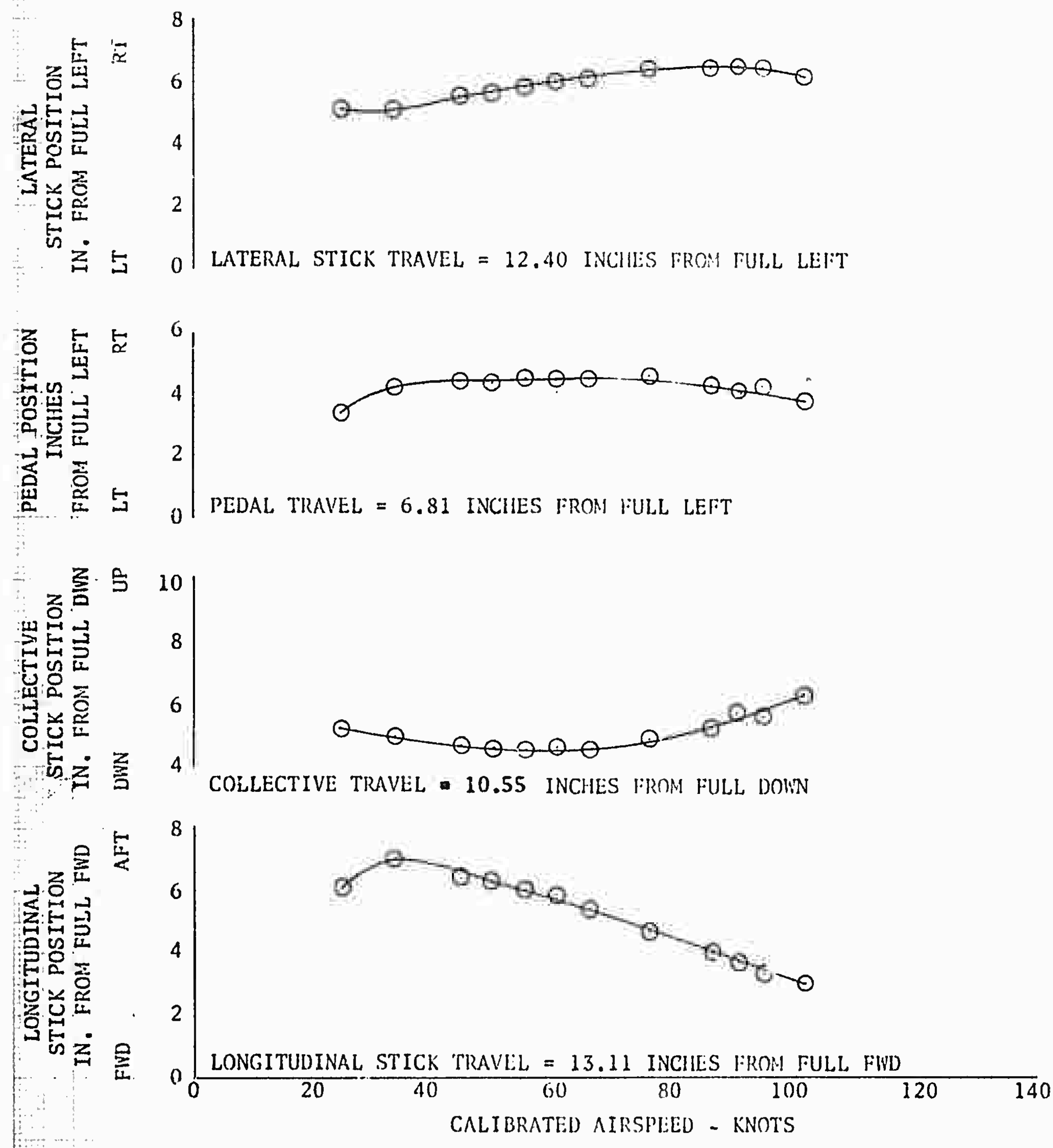


FIGURE NO. 15
CONTROL POSITIONS IN LEVEL FLIGHT
UH-1B/540 USA S/N 64-14105
XM-159/M-5 ARMAMENT SUBSYSTEM
PODS EMPTY

AVERAGE GROSS WEIGHT = 8165 LB
AVERAGE DENSITY ALTITUDE = 6240 FT
C.G. LOCATION = 126.7 IN
ROTOR SPEED = 324 RPM

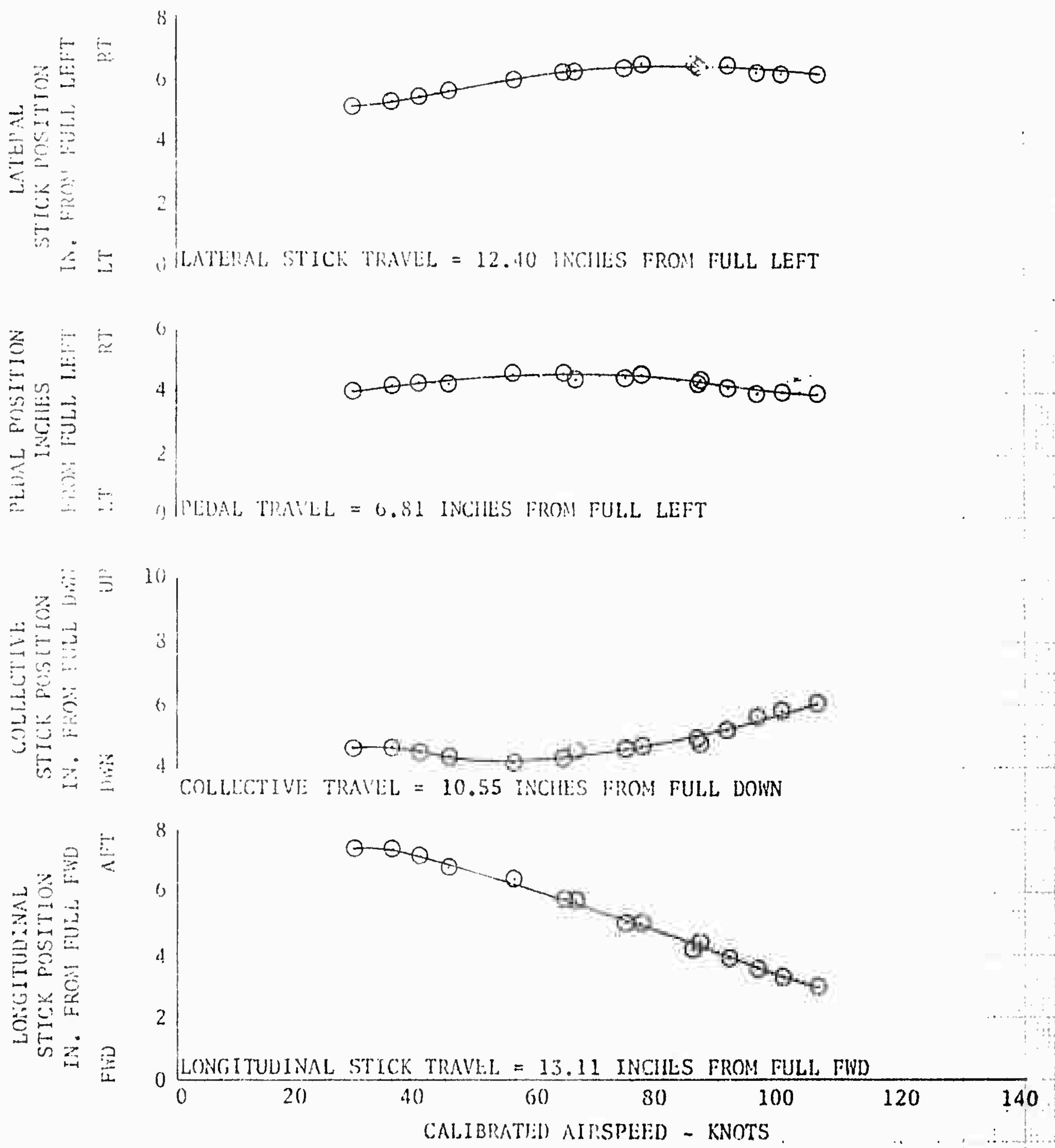


FIGURE NO. 16
CONTROL POSITIONS IN LEVEL FLIGHT
UH-1B/540 USA S/N 64-14105
XM-159/M-5 ARMAMENT SUBSYSTEM
PODS EMPTY
AVERAGE GROSS WEIGHT = 8620 LB
AVERAGE DENSITY ALTITUDE = 10,480 FT
C.G. LOCATION = 126.7 IN
ROTOR SPEED = 324 RPM

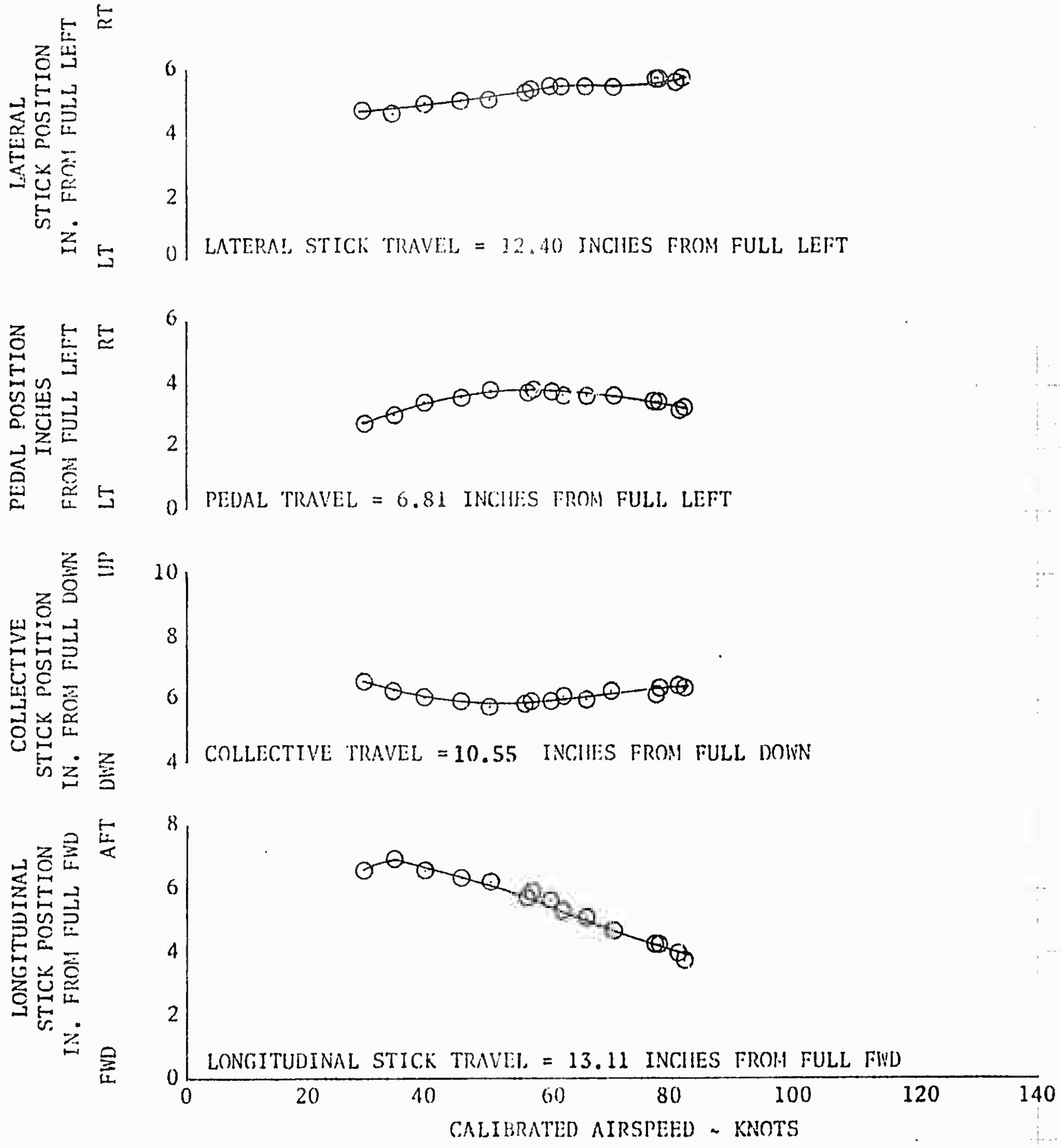


FIGURE NO. 17
STATIC LONGITUDINAL SPEED STABILITY
UH-1B/540 USA S/N 64-14105
XM-159/M-5 ARMAMENT SUBSYSTEM
LEVEL FLIGHT EMPTY PODS

SYM	TRIM CALIBRATED AIRSPEED KT	DENSITY ALTITUDE FT	C.G. STATION IN	GROSS WEIGHT LB	ROTOR SPEED RPM
○	103.5	4850	127.0	8920	324.0
□	83.5	4820	126.8	8685	324.5
△	40.5	5040	126.6	8560	323.5

NOTE: SHADED SYMBOLS DENOTE TRIM POINTS

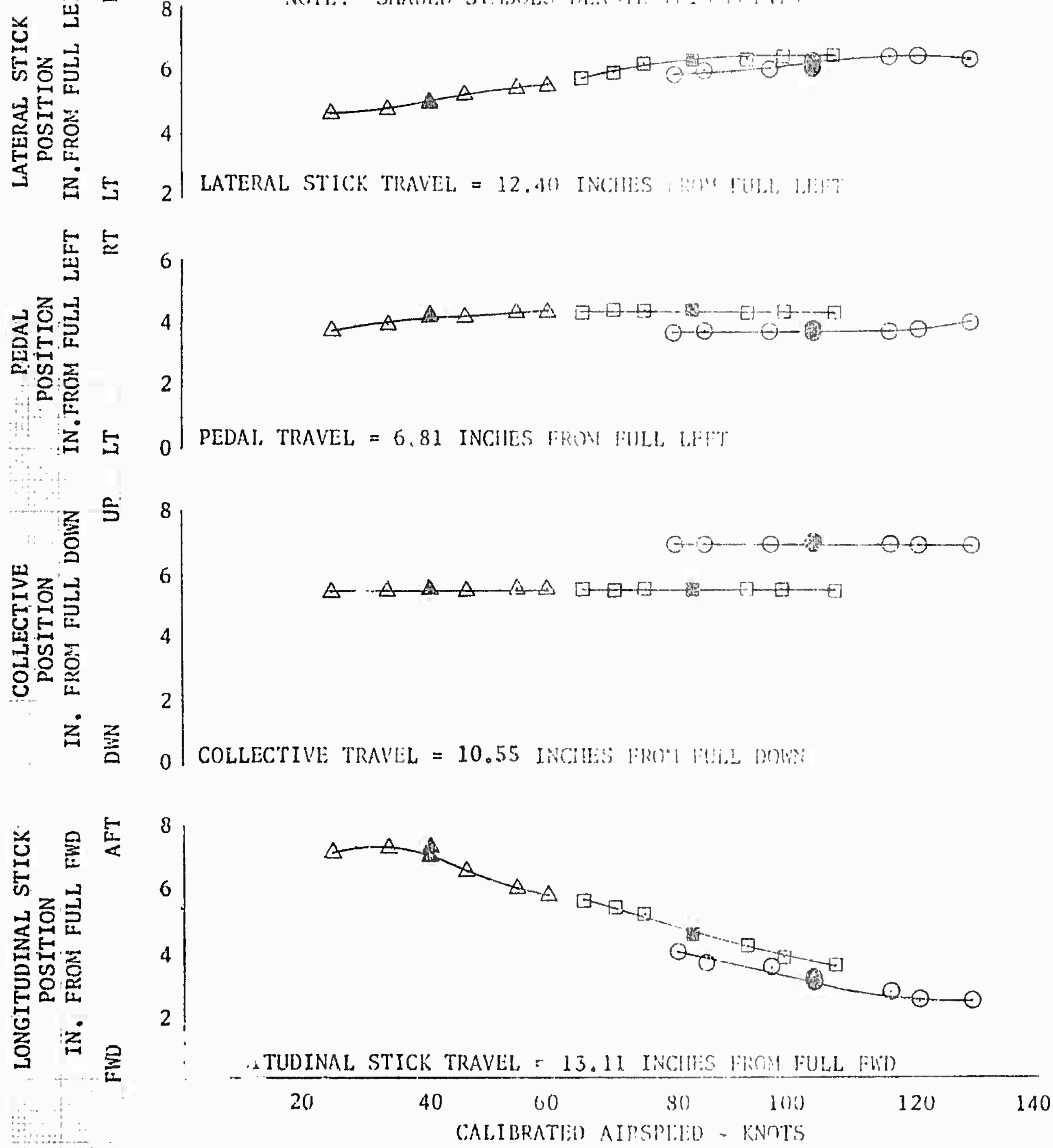


FIGURE NO. 18
STATIC LATERAL DIRECTIONAL STABILITY
UH-1B/540 USA S/N 64-14105
XM-159/M-5 ARMAMENT SUBSYSTEM
LEVEL FLIGHT PODS EMPTY

GROSS WEIGHT = 8690 LB
DENSITY ALTITUDE = 4460 FT
ROTOR SPEED = 324 RPM
C.G. LOCATION = 126.9 IN
V_{CAL} = 83.5 KT

SYM
O PITCH ANGLE θ
□ ROLL ANGLE ϕ

NOTE: SHADED SYMBOLS DENOTE TRIM POINTS

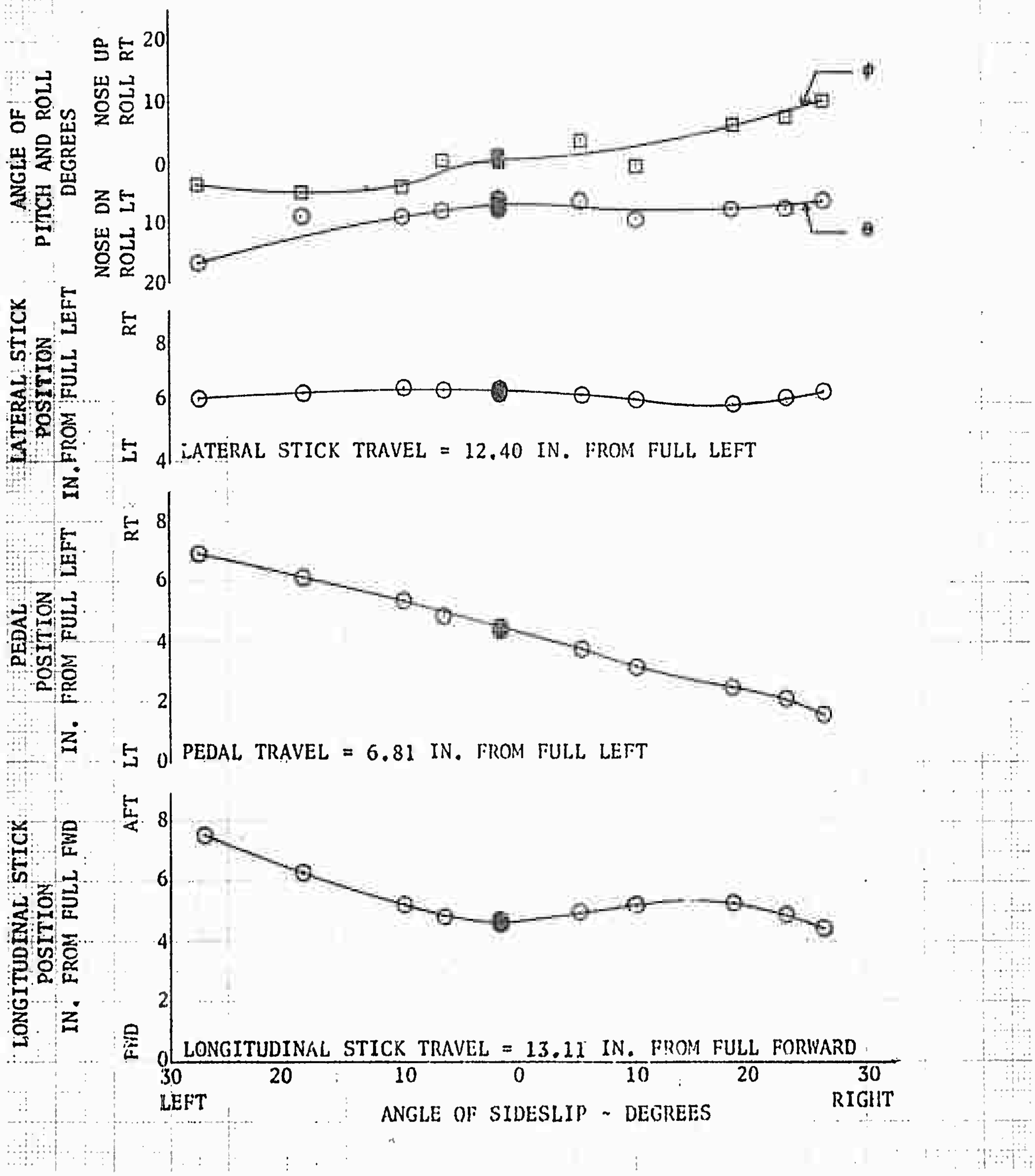


FIGURE NO. 19

STATIC LATERAL DIRECTIONAL STABILITY

UH-1B/540 USA S/N 64-14105

XM-157/M-5 ARMAMENT SUBSYSTEM

LEVEL FLIGHT POOS EMPTY

GROSS WEIGHT = 8805 LB

DENSITY ALTITUDE = 4830 FT

ROTOR SPEED = 324 RPM

C.G. LOCATION = 127.0 IN

SYM

○ PITCH ANGLE θ

□ ROLL ANGLE ϕ

NOTE: SHADED SYMBOLS DENOTE TRIM POINTS

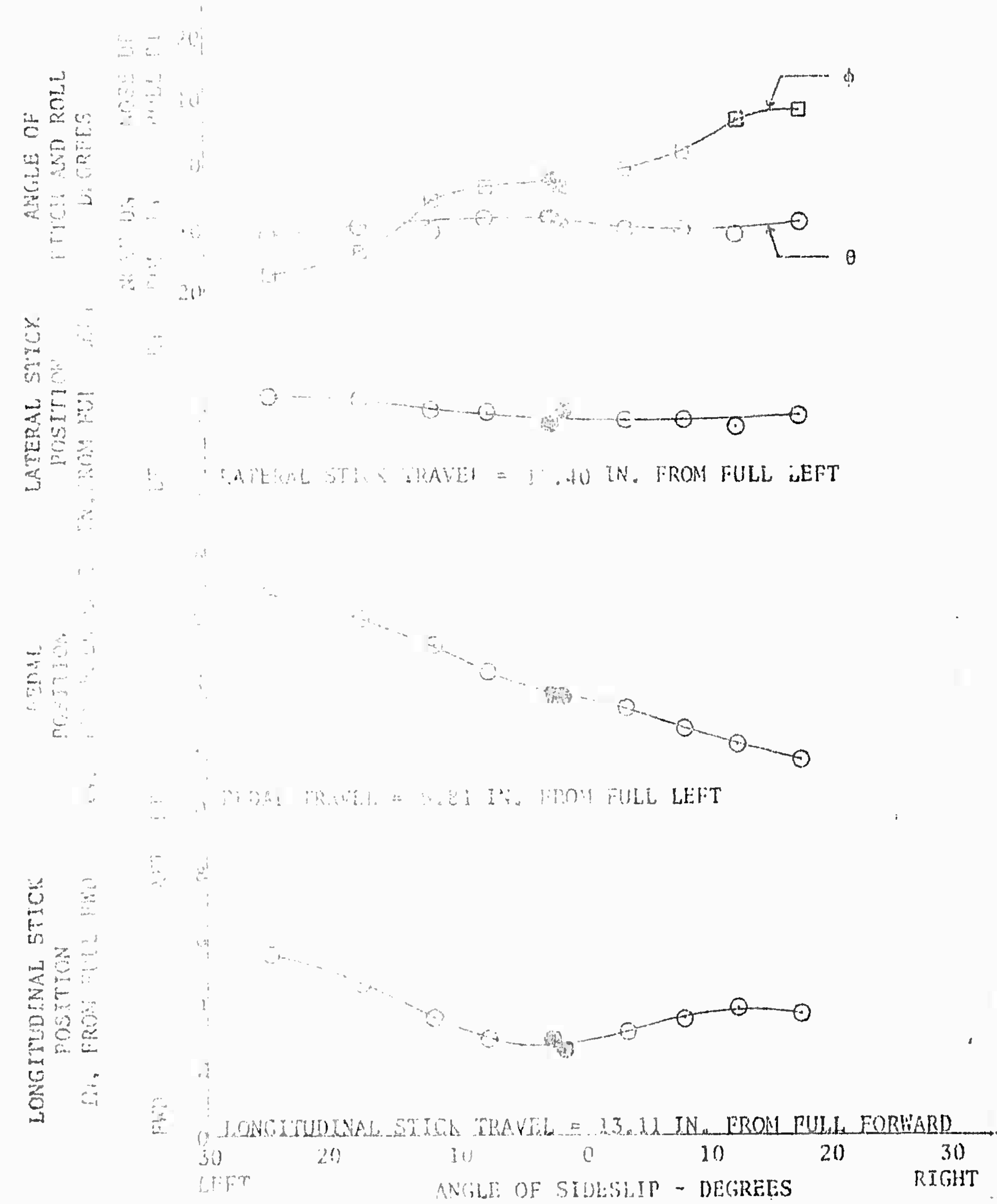


FIGURE NO. 20
STATIC LATERAL DIRECTIONAL STABILITY
UH-1B/540 USA S/N 64-14105
XM-159/M-5 ARMAMENT SUBSYSTEM
MAXIMUM POWER DESCENT PODS EMPTY

GROSS WEIGHT = 8540 LB
DENSITY ALTITUDE = 3870 FT
ROTOR SPEED = 324 RPM
C.G. LOCATION = 126.6 IN
V_{CAL} = 121 KT

SYM
○ PITCH ANGLE θ
□ ROLL ANGLE φ

NOTE: SHADED SYMBOLS DENOTE TRIM POINTS.

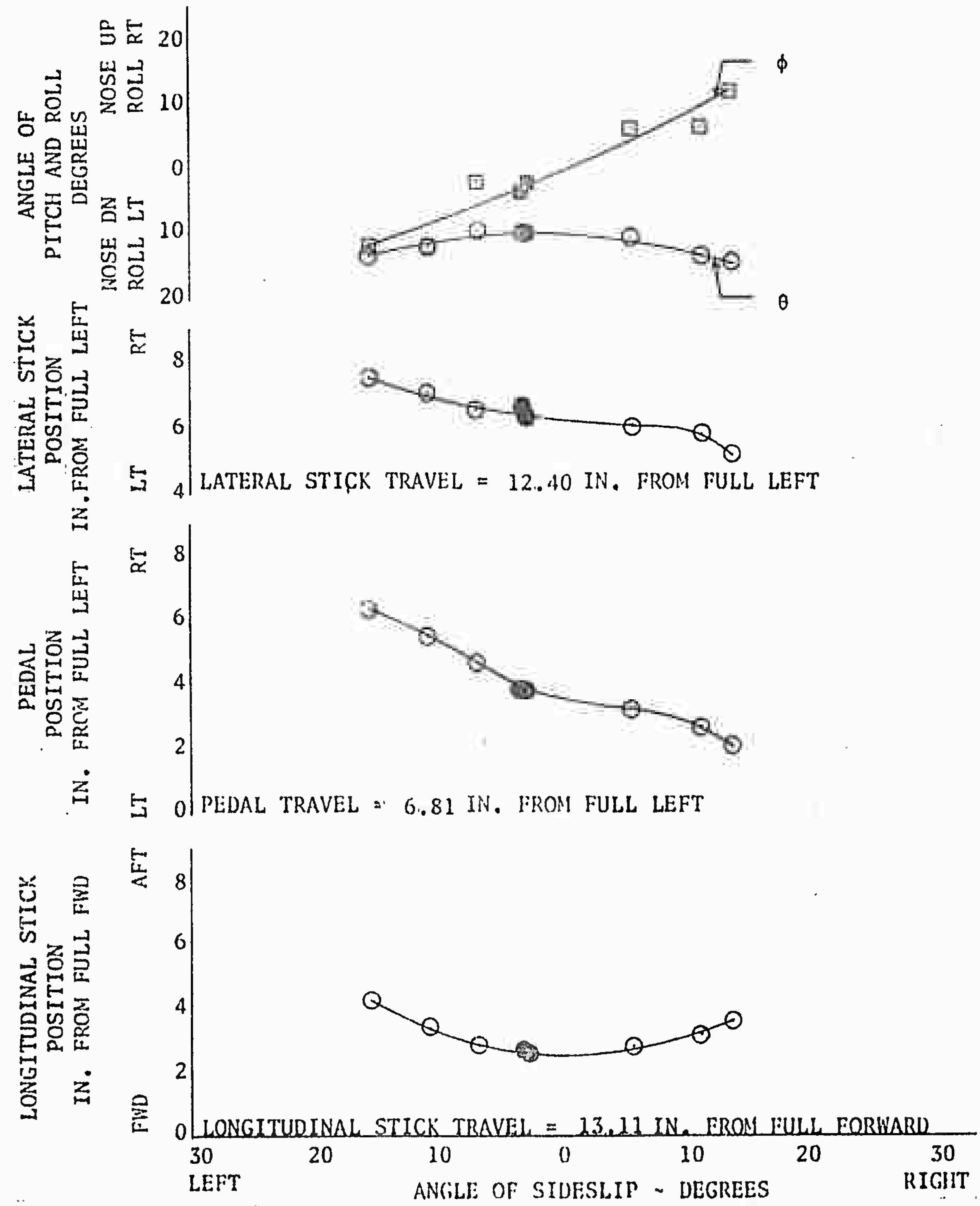


FIGURE NO. 21
LONGITUDINAL CONTROLLABILITY
UH-1B/540 USA S/N 64-14105
XM-159/M-5 ARMAMENT SUBSYSTEM (PODS EMPTY)

SYM	GROSS WEIGHT LB	ROTOR SPEED RPM	DENSITY ALTITUDE FT	CALIBRATED AIRSPEED KTS	C.G. STATION IN	FLIGHT CONDITION
○	8590	324	5000	106	126.6	LEVEL FLIGHT
□	7800	324	5000	108	126.7	LEVEL FLIGHT

TOTAL LONGITUDINAL STICK TRAVEL = 13.11 IN FROM FULL FORWARD

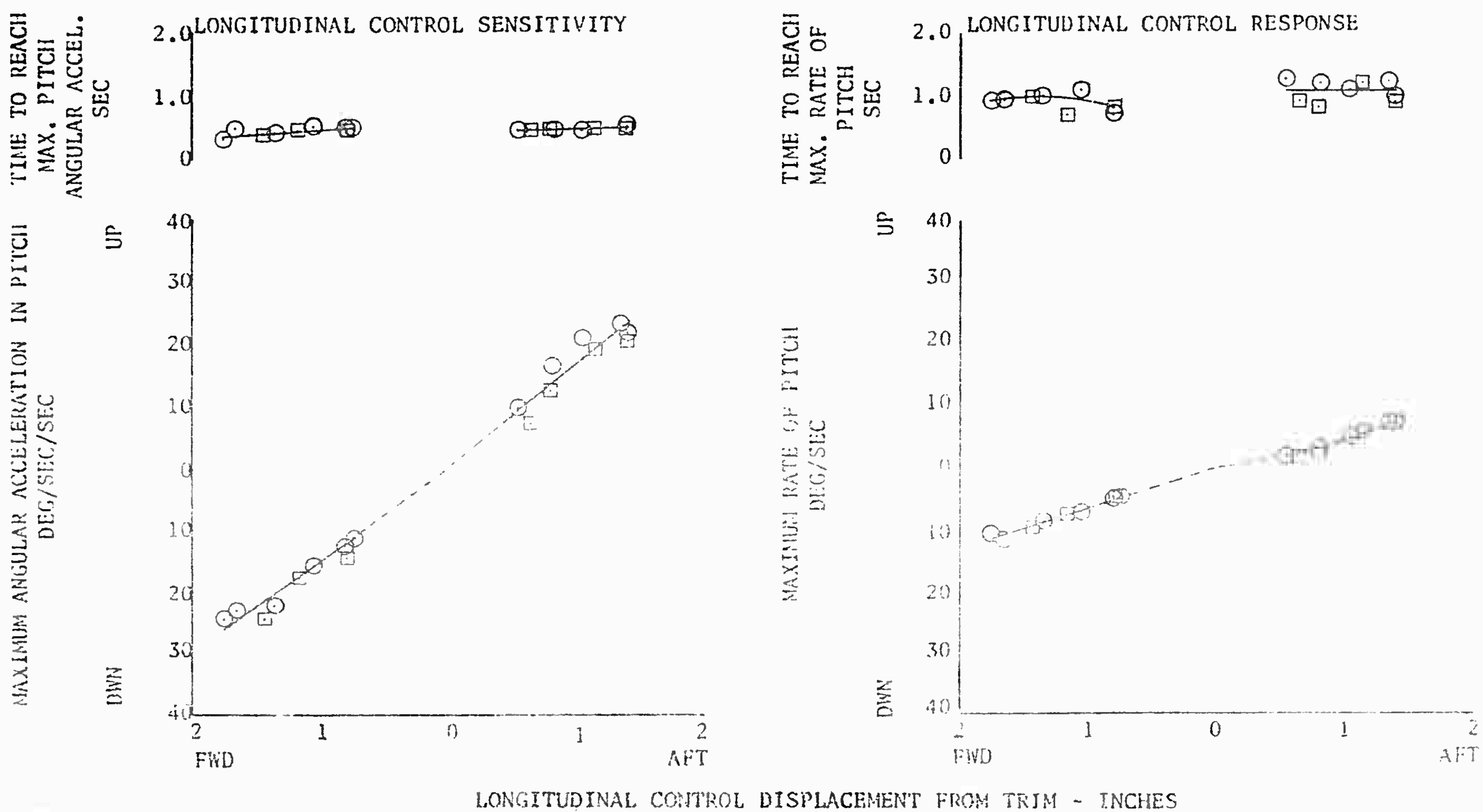


FIGURE NO. 22
LATERAL CONTROLLABILITY
UH-1B/540 USA S/N 64-14105
XM-159/M-5 ARMAMENT SUBSYSTEM
PODS EMPTY

SYM	GROSS WEIGHT LB	ROTOR SPEED RPM	DENSITY ALTITUDE FT	CALIBRATED AIRSPEED KTS	C.G. STATION IN	FLIGHT CONDITION
○	8345	324	5000	106	126.4	LEVEL FLIGHT
□	7615	324	5000	108	126.5	LEVEL FLIGHT

TOTAL LATERAL STICK TRAVEL = 12.40 IN. FROM FULL LEFT

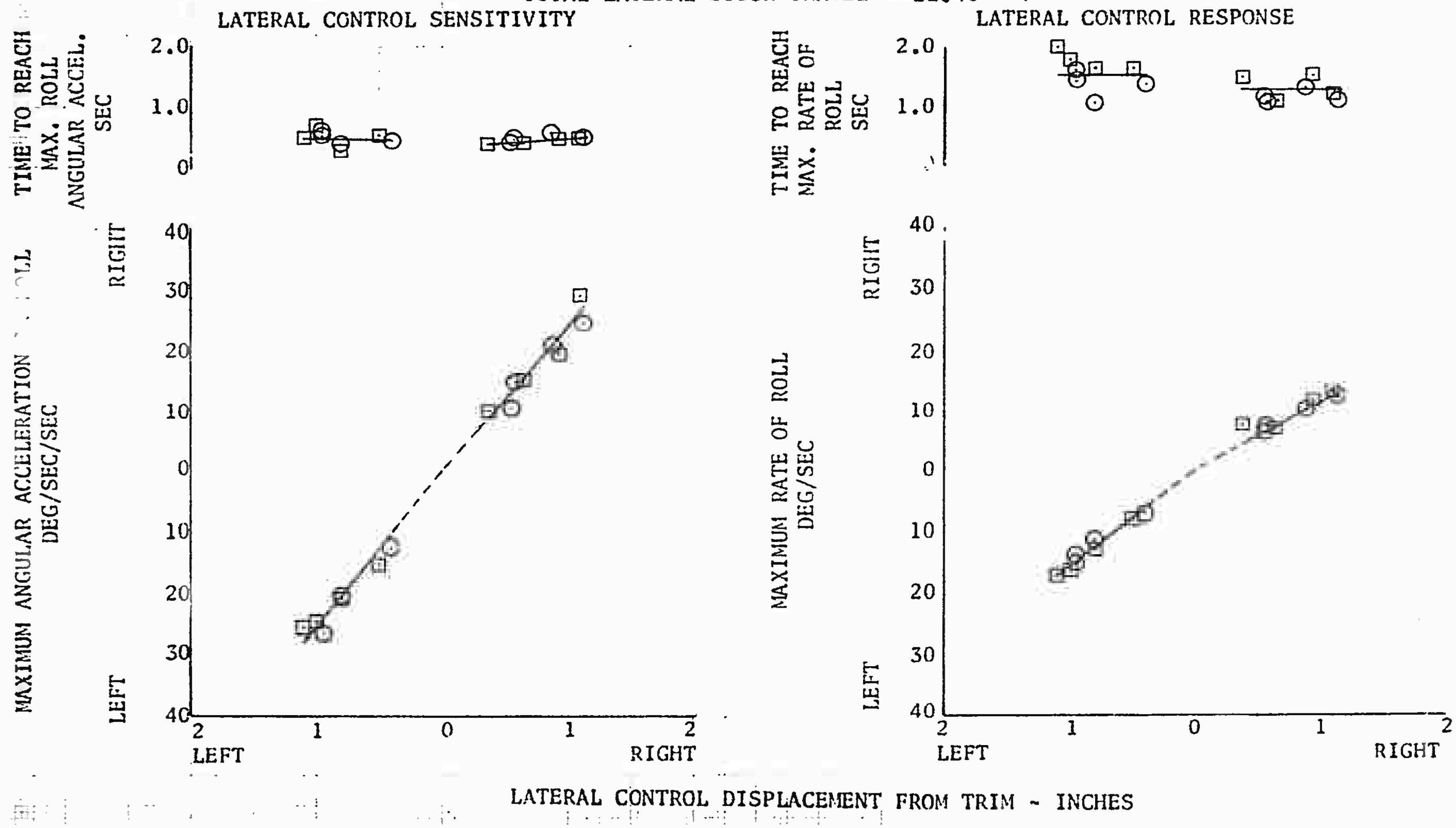


FIGURE NO. 23
DIRECTIONAL CONTROLLABILITY
UH-1B/540 USA S/N 64-14105
XM-159/M-5 ARMAMENT SUBSYSTEM (PODS EMPTY)

SYM	GROSS WEIGHT LB	ROTOR SPEED RPM	DENSITY ALTITUDE FT	CALIBRATED AIRSPEED KTS	C.G. STATION IN	FLIGHT CONDITION
○	8055	324	5000	106	126.1	LEVEL FLIGHT
□	7430	324	5000	108	126.3	LEVEL FLIGHT

TOTAL PEDAL TRAVEL = 6.81 IN. FROM FULL LEFT

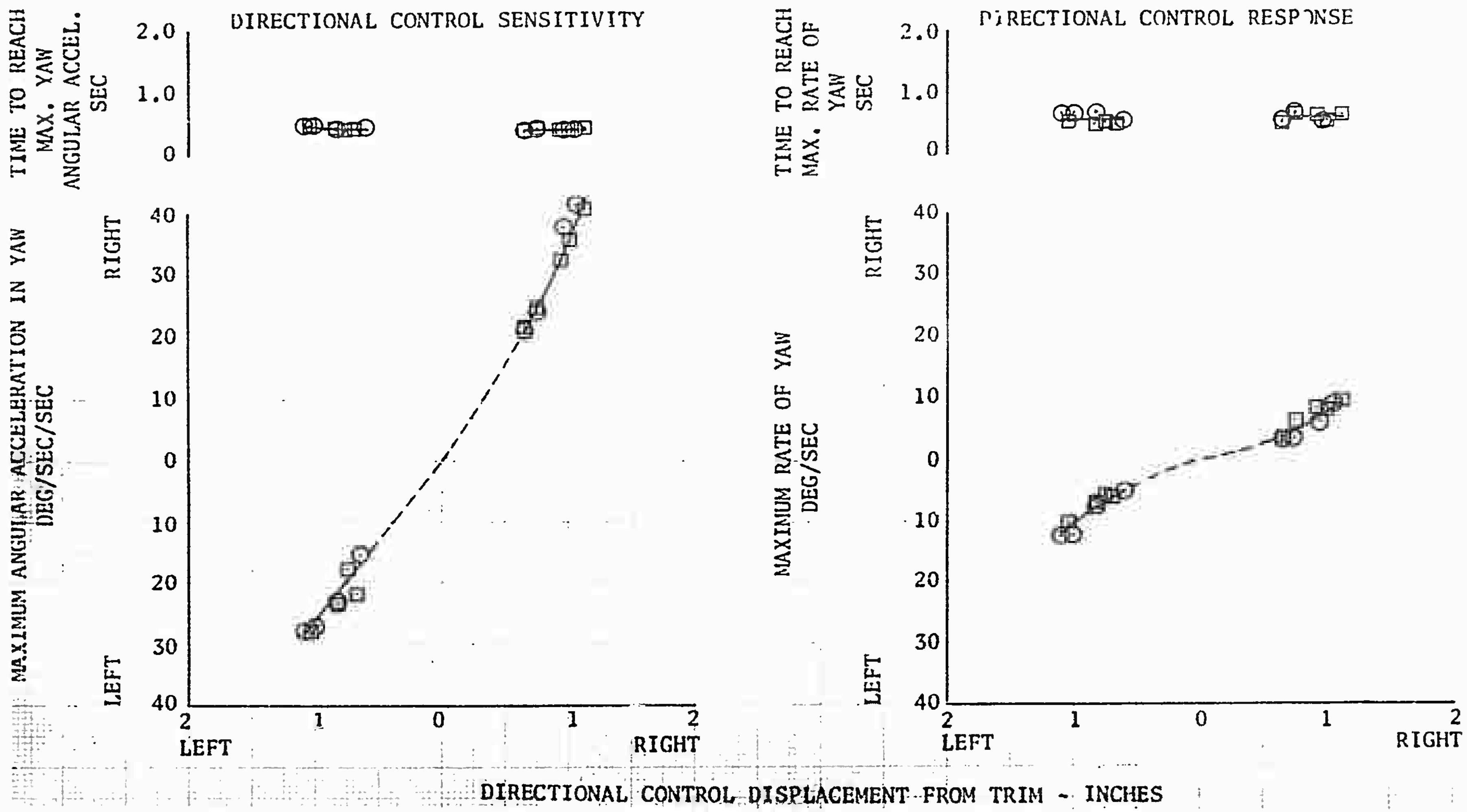


FIGURE NO. 24
REACTION TO RIGHT LATERAL PULSE
LEVEL FLIGHT
UH-1B/540 USA S/N 64-14105
XM-159/M-5 ARMAMENT SUBSYSTEM (PODS EMPTY)

C.G. STATION IN	GROSS WEIGHT LB	DENSITY ALTITUDE FT	ROTOR SPEED RPM	CALIBRATED AIRSPEED KT
126.4	7455	5000	324	108

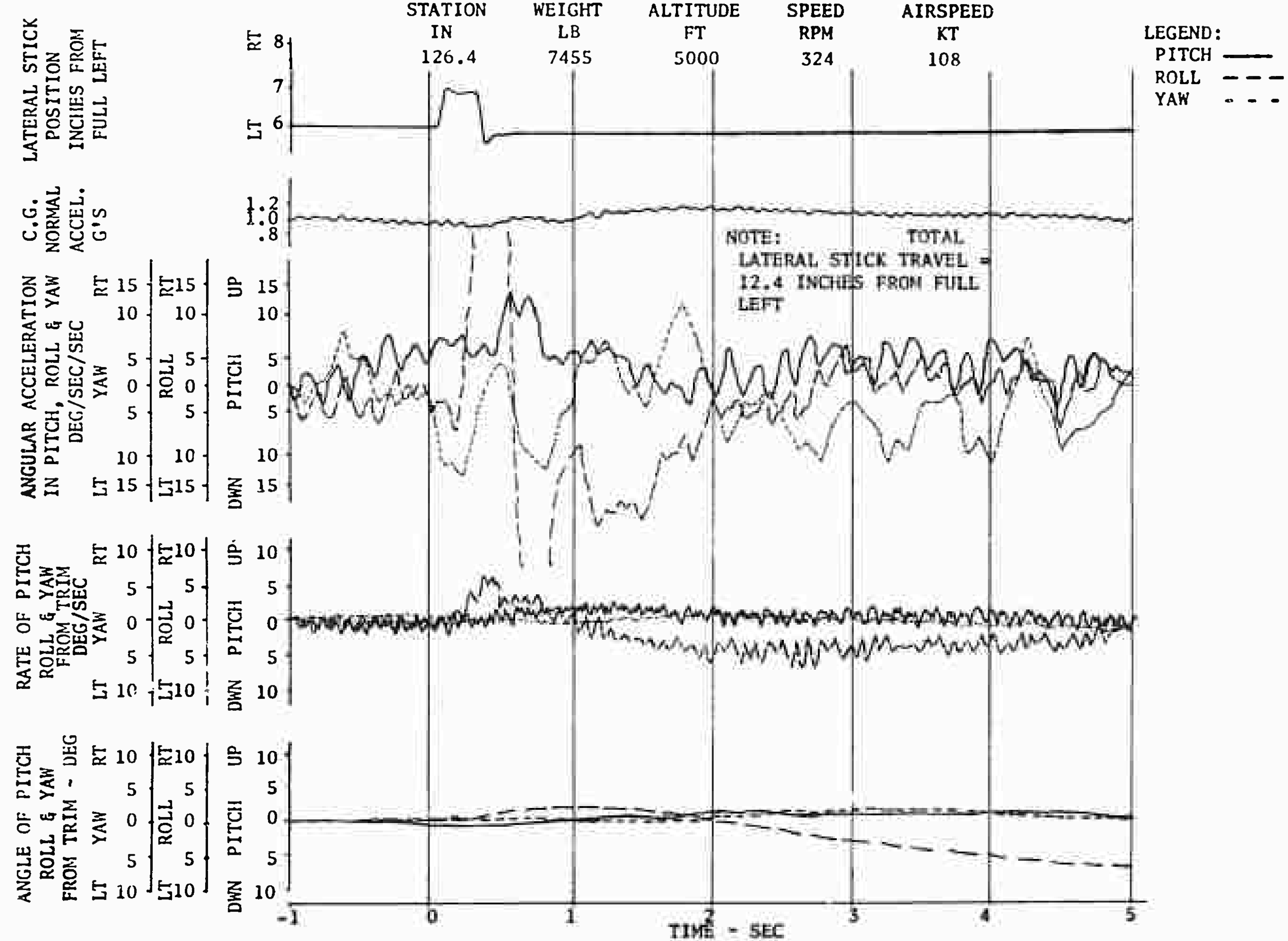


FIGURE NO. 25
REACTION TO AFT LONGITUDINAL PULSE
LEVEL FLIGHT
UH-1B/540 USA S/N 64-14105

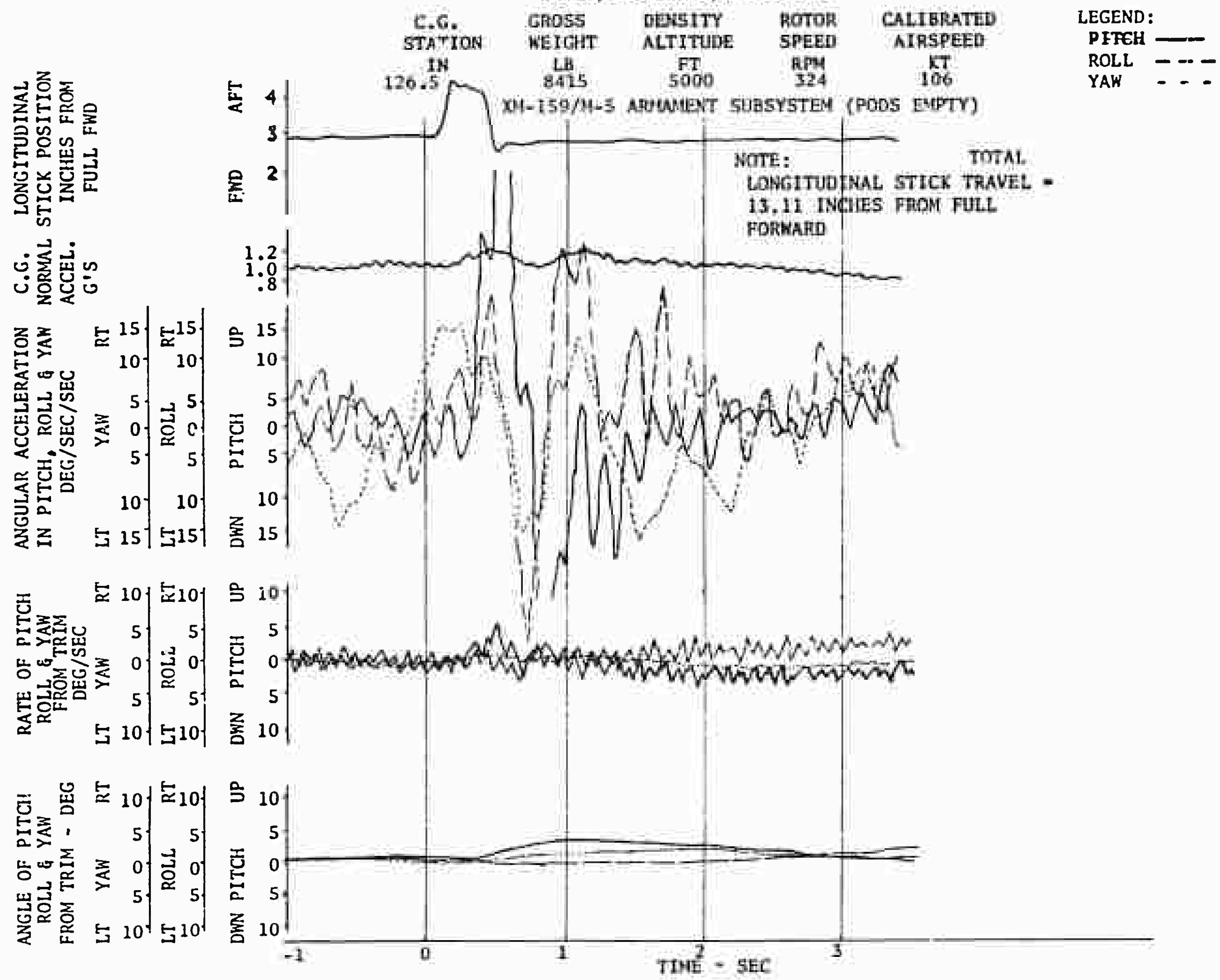


FIGURE NO. 26
REACTION TO RIGHT DIRECTIONAL PULSE
LEVEL FLIGHT
UH-1B/540 USA S/N 64-14105

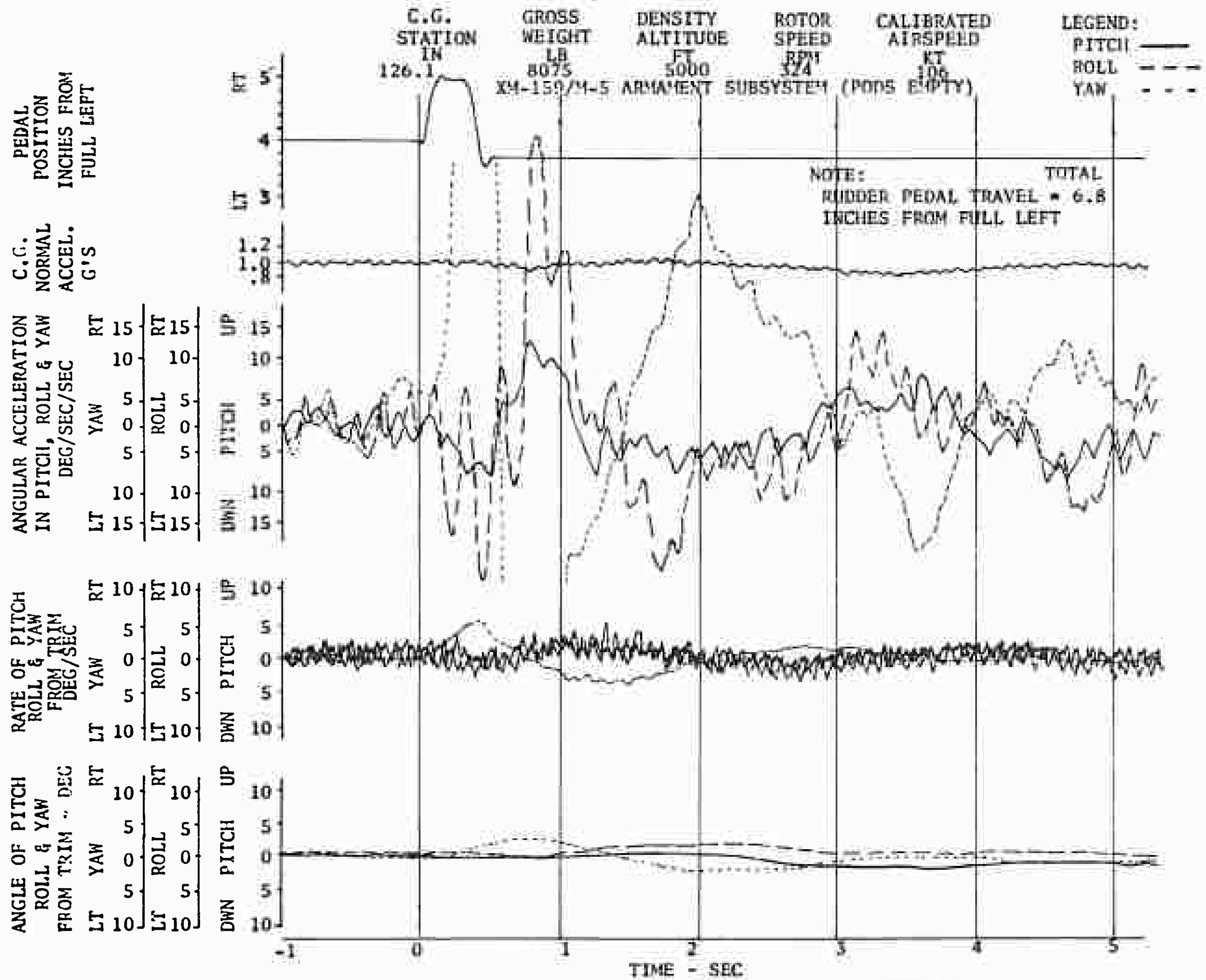


FIGURE NO. 27
TIME HISTORY OF XM-159 WEAPONS FIRING
UH-1B/540 USA S/N 64-14105
LEVEL FLIGHT

C.G. STATION IN	GROSS WEIGHT LB	DENSITY ALTITUDE FT	ROTOR SPEED RPM	CALIBRATED AIRSPEED KT
128.7	7935	6800	324	100

LEGEND:
PITCH ——
ROLL — — —
YAW - - -

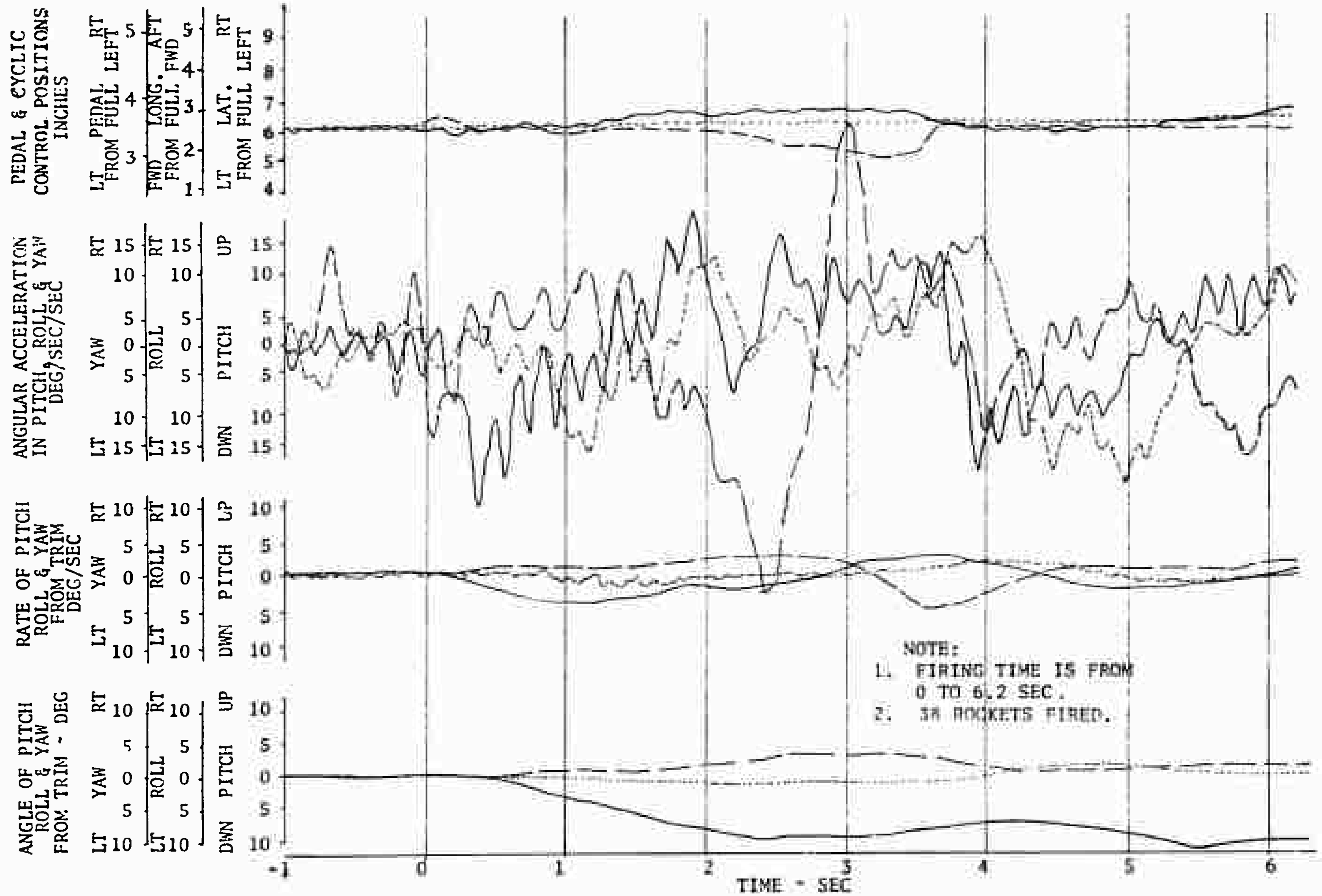


FIGURE NO. 28
RECOMMENDED XM-158 JETTISON ENVELOPE
FOR CLIMB, LEVEL FLIGHT, AND MAXIMUM POWER DESCENT
UH-1B/540

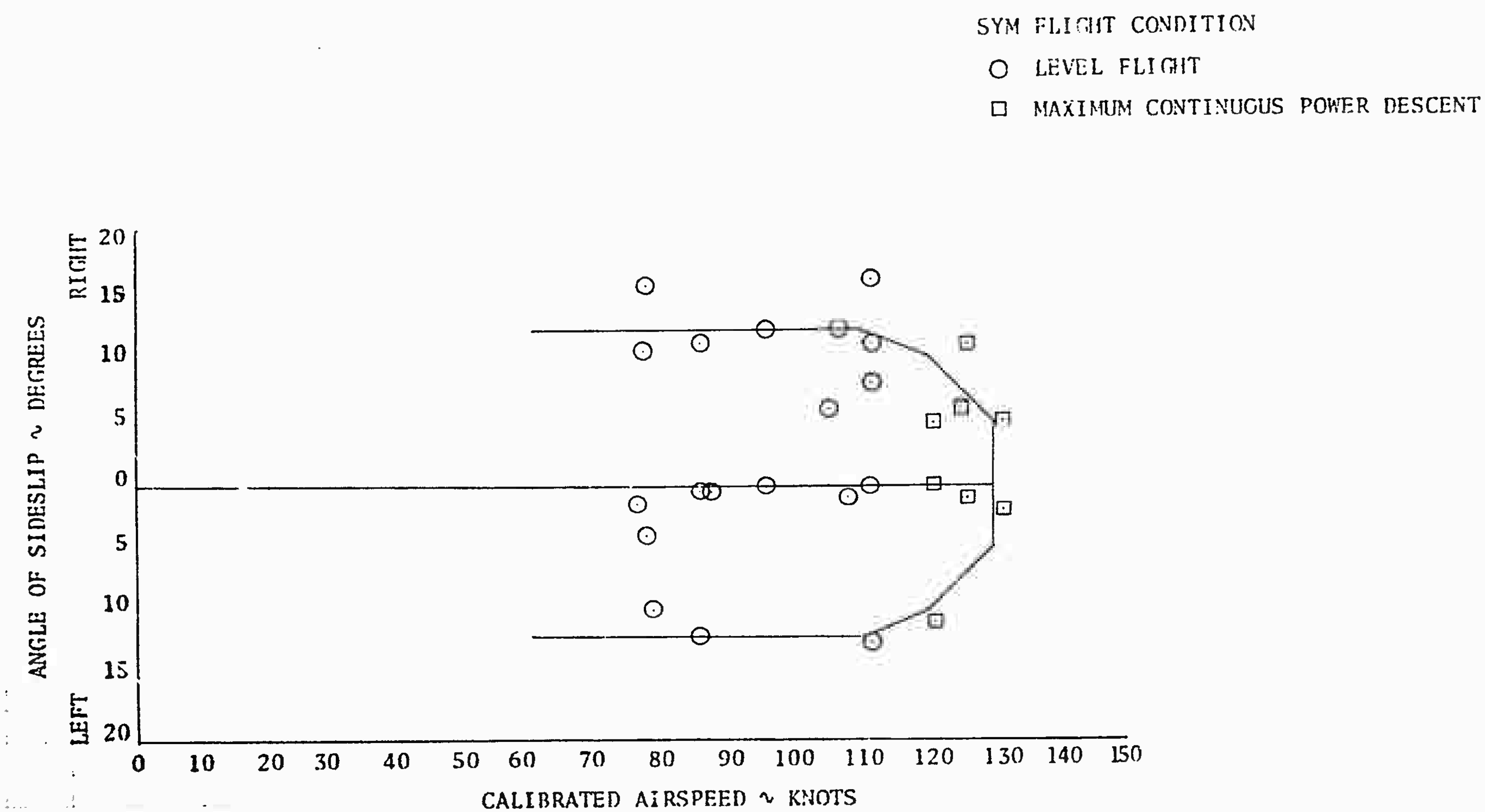
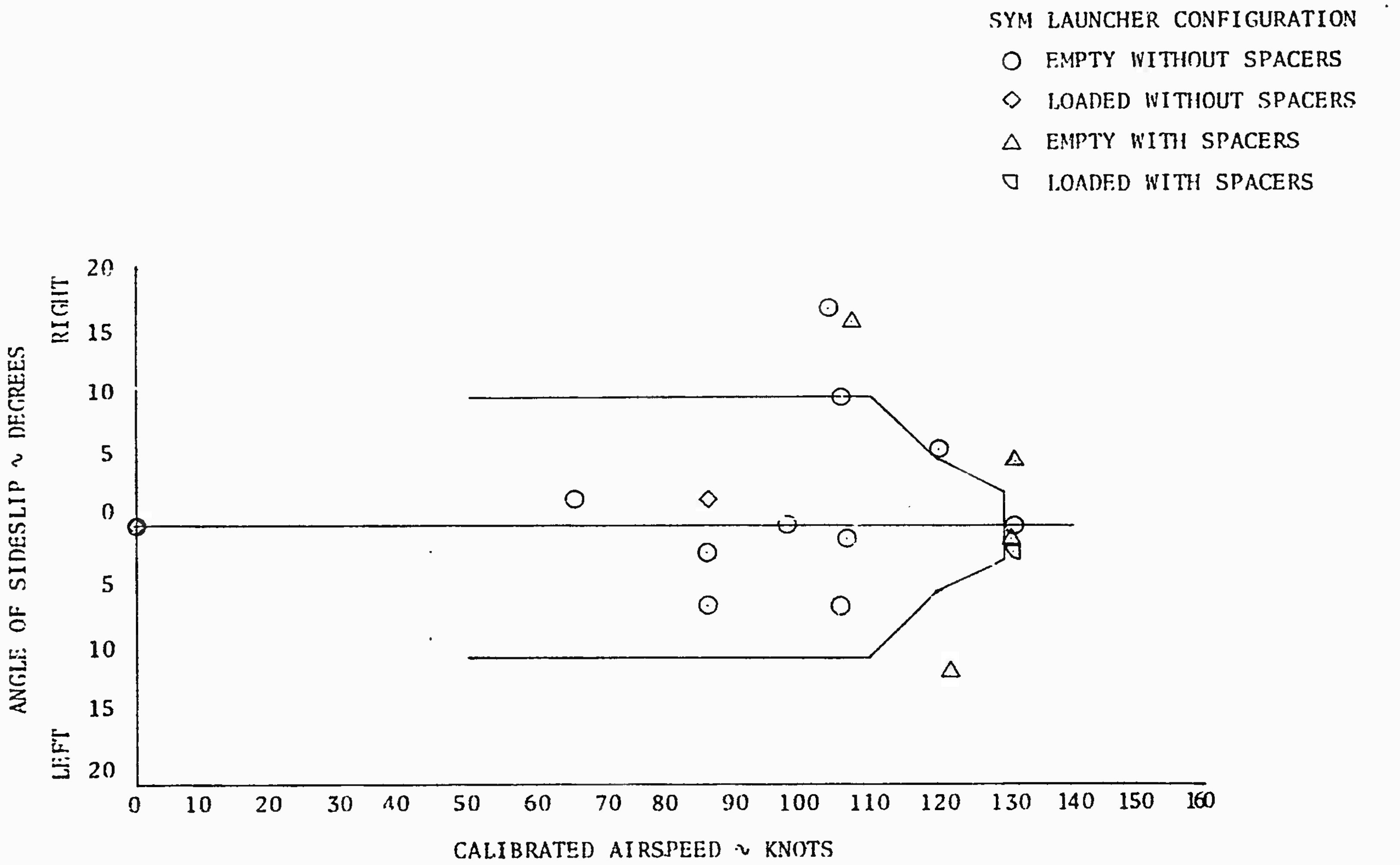


FIGURE NO. 29
RECOMMENDED XM-159 JETTISON ENVELOPE
FOR CLIMB, LEVEL FLIGHT, AND MAXIMUM POWER DESCENT
UH-1B/540



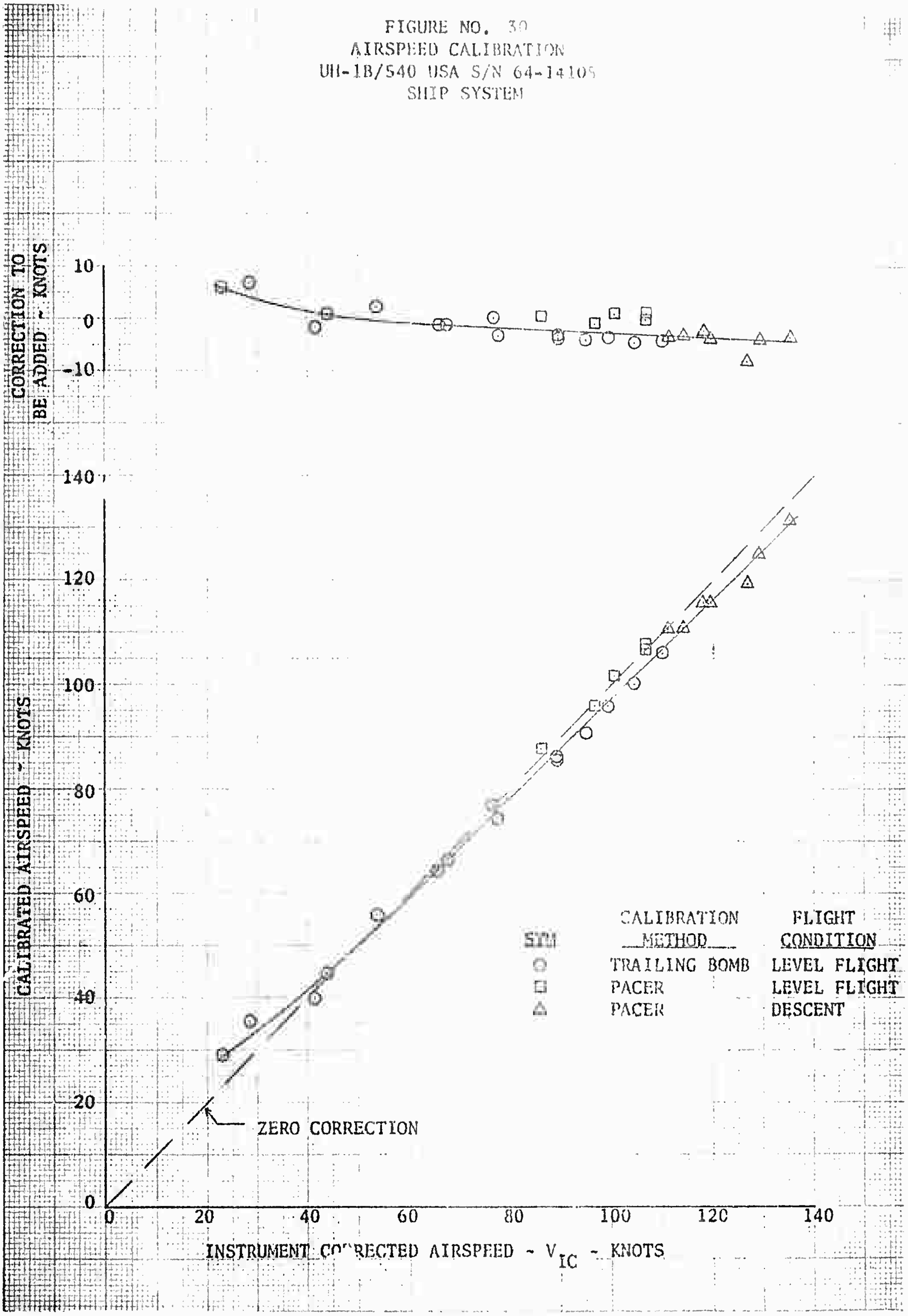


FIGURE NO. 30
AIRSPEED CALIBRATION
UH-1B/540 USA S/N 64-14105
SHIP SYSTEM
CORRECTION TO BE ADDED - KNOTS
10
0
-10
CALIBRATED AIRSPEED - KNOTS
140
120
100
80
60
40
20
0
SYM
CALIBRATION METHOD
FLIGHT CONDITION
TRAILING BOMB
LEVEL FLIGHT
PACER
LEVEL FLIGHT
PACER
DESCENT
ZERO CORRECTION
0
20
40
60
80
100
120
140
INSTRUMENT CORRECTED AIRSPEED - V_{IC} - KNOTS

FIGURE NO. 31
ENGINE TORQUEMETER CALIBRATION
UH-1B/540 USA S/N 64-14105

NOTE:
DATA TAKEN FROM LYCOMING "GREEN RUN"
SHEETS DATA 19 MARCH 1965
ENGINE MODEL T53-L-11
ENGINE SERIAL NO. LE 10382

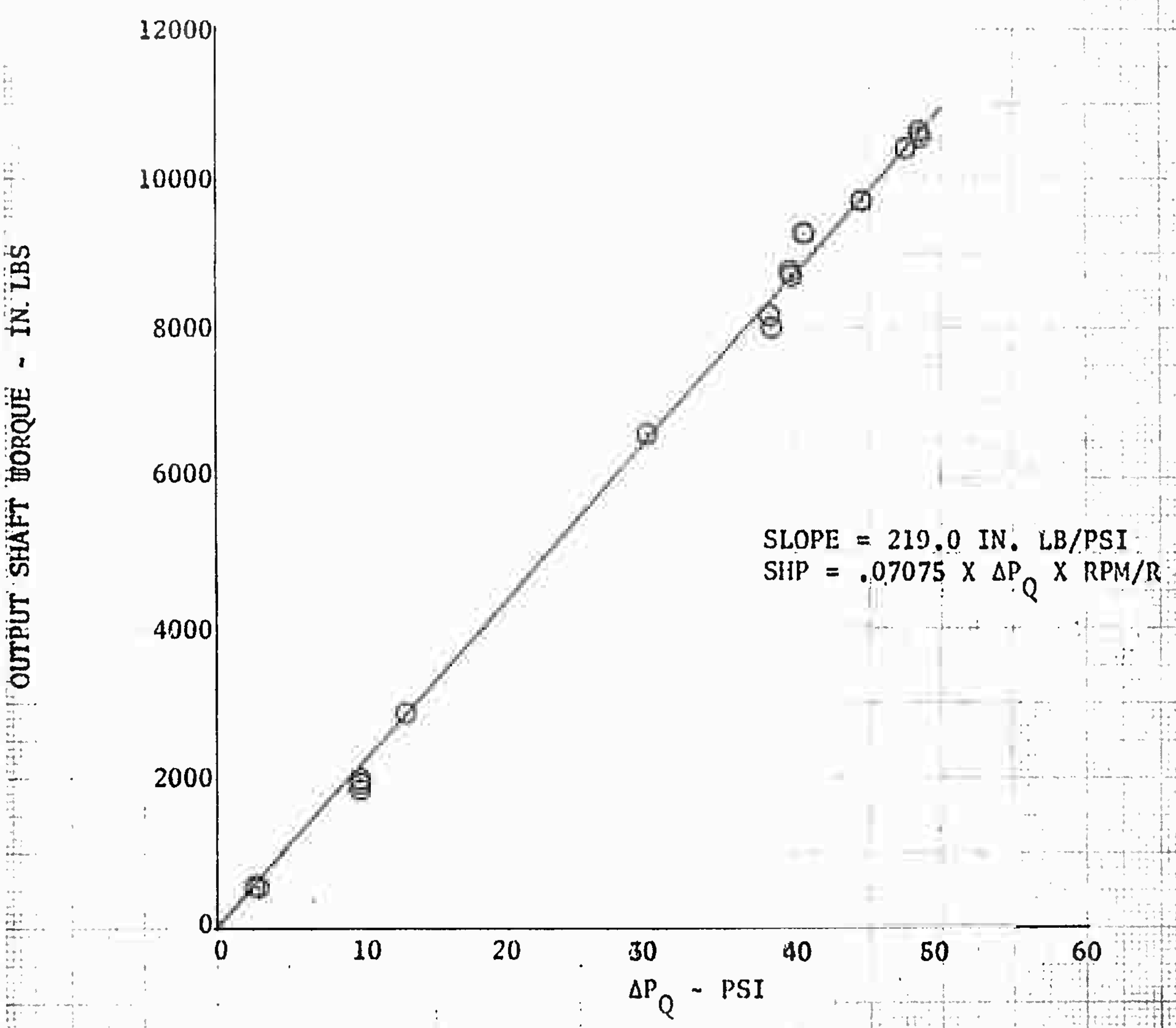


FIGURE NO. 32
ENGINE CHARACTERISTICS
UH-1B/540 USA S/N 64-14105
T53-L-11 ENGINE S/N LE 10382

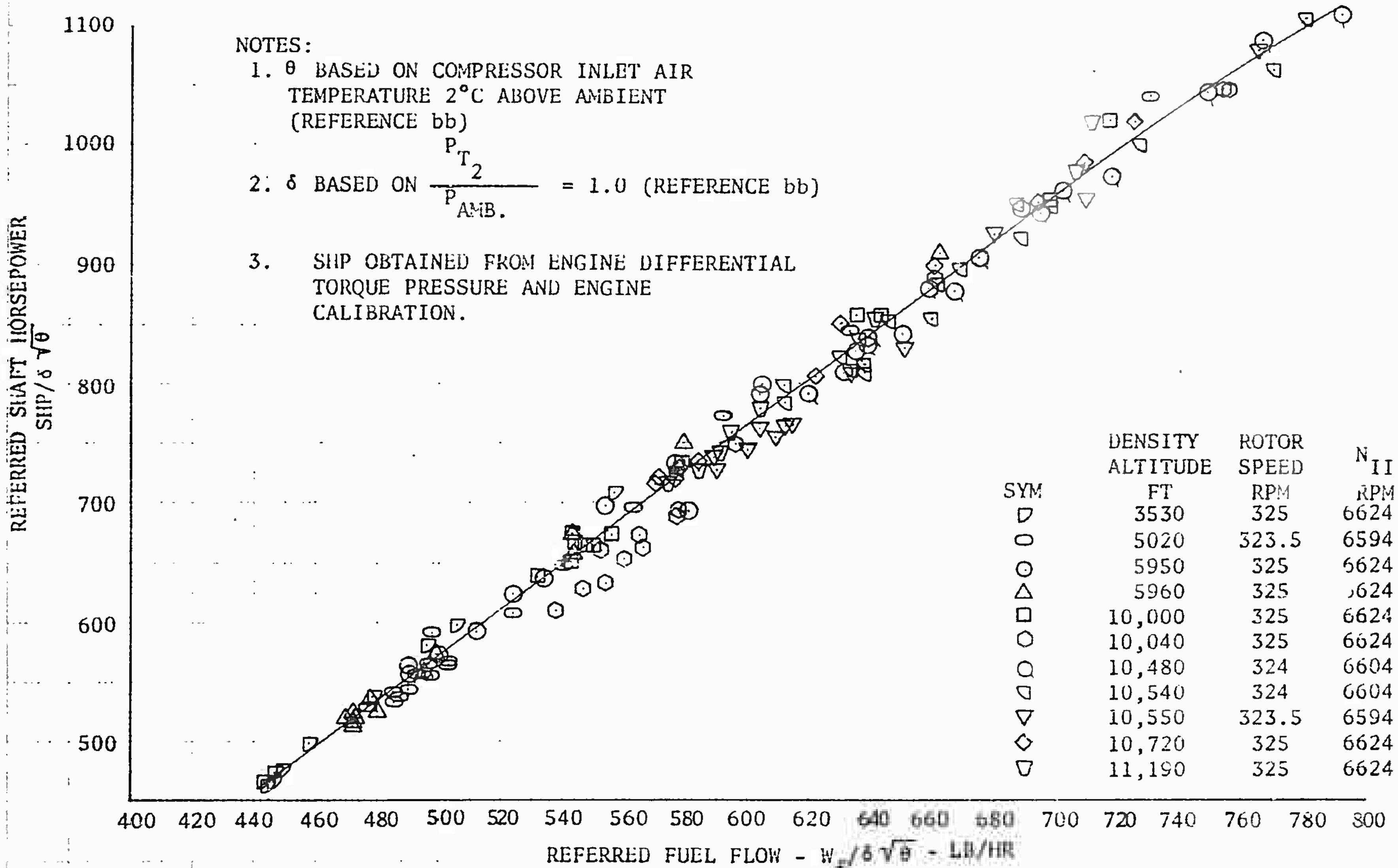


FIGURE 33

SPECIFICATION FUEL FLOW

UH-1B/540 USA S/N 64-14106

BELL MODEL 540 ROTOR SYSTEM

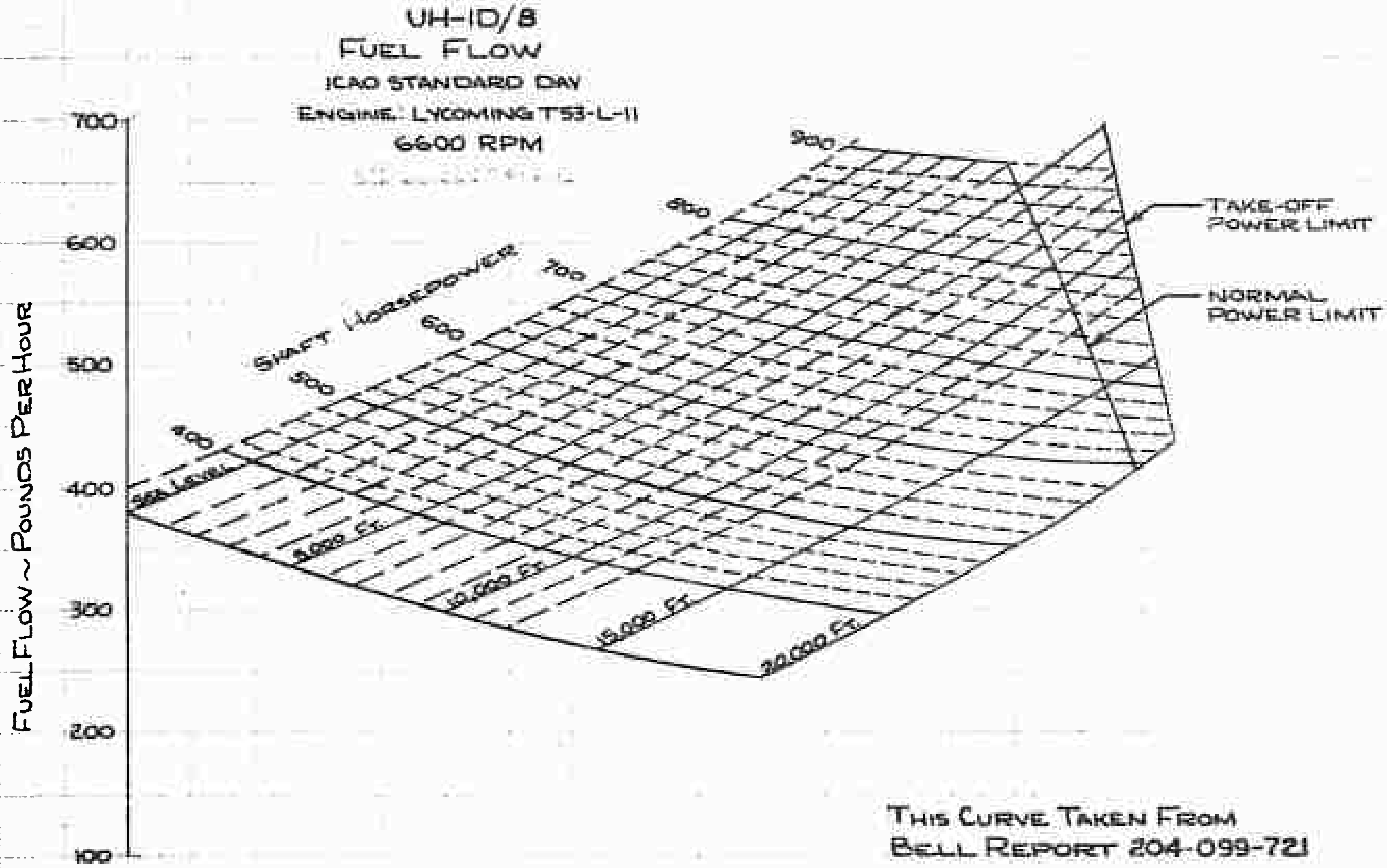


FIGURE NO. 54

NORMAL RATED SHAFT HORSEPOWER AVAILABLE

UH-1B/540 USA S/N 64-14105

T53-L-11 ENGINE

NOTES:

1. SHAFT HORSEPOWER AVAILABLE BASED ON LYCOMING T53-L-11 ENGINE MODEL SPECIFICATION
2. COMPRESSOR INLET TEMPERATURE RISE = +2°C
3. COMPRESSOR INLET PRESSURE RATIO $\left(\frac{P_{T_2}}{P_A}\right)$ = 1.00
4. GENERATOR ELECTRICAL LOAD = ZERO
5. PERCENT AIR BLEED $\left(\frac{W_{bl}}{W_A}\right)$ = 0.5%
6. ROTOR SPEED = 324 RPM

THIS CURVE TAKEN FROM REFERENCE bb , FIGURE 224.

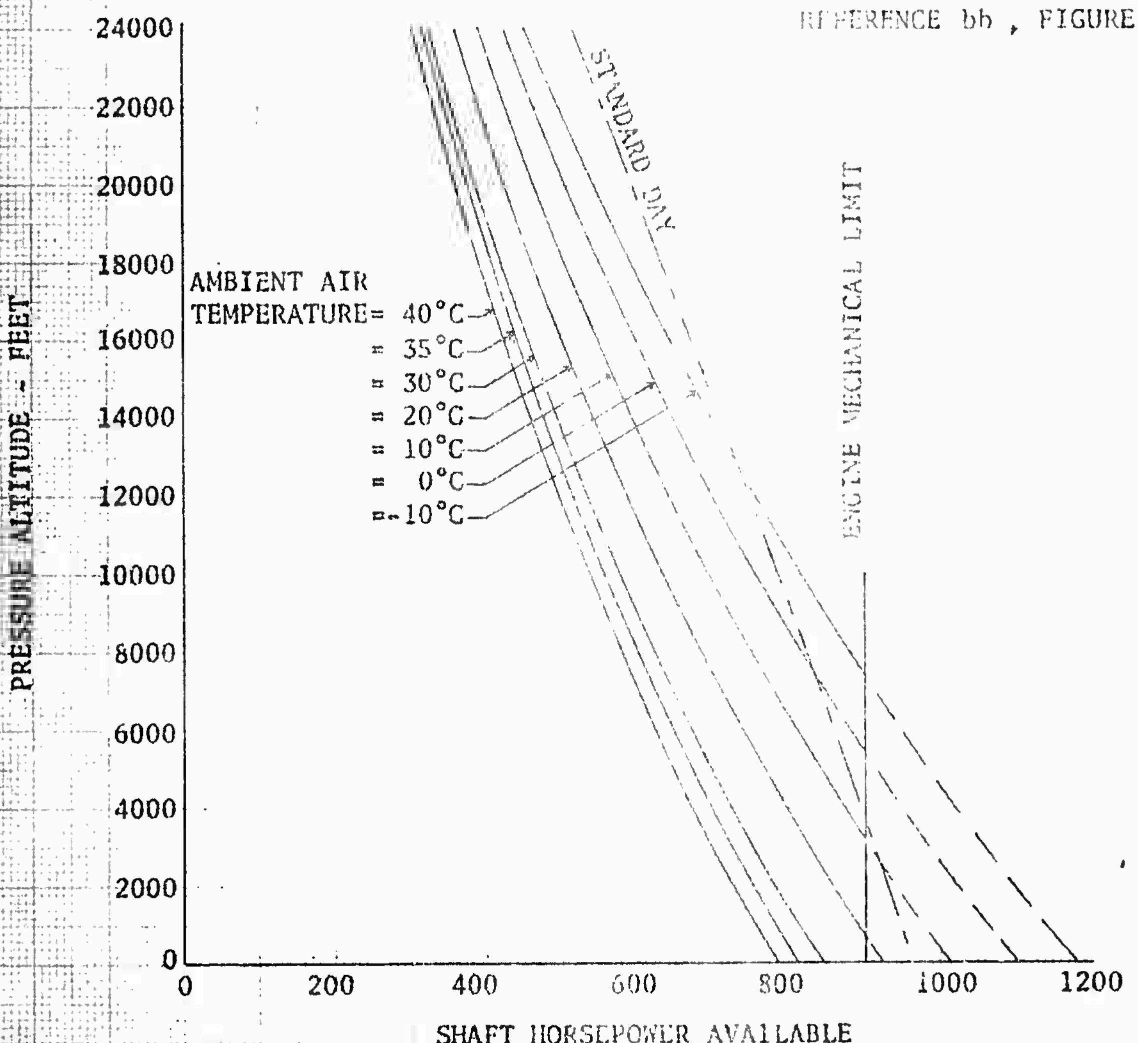


FIGURE NO. 35

TAKEOFF LIMIT SHAFT HORSEPOWER AVAILABLE

UH-1B/540 USA S/N 64-14105

T53-L-11 ENGINE

NOTES:

1. SHAFT HORSEPOWER AVAILABLE BASED ON LYCOMING T53-L-11 ENGINE MODEL SPECIFICATION
2. COMPRESSOR INLET TEMPERATURE RISE = +2°C
3. COMPRESSOR INLET PRESSURE RATIO $\left(\frac{P_{T_2}}{P_A}\right) = 1.00$
4. GENERATOR ELECTRICAL LOAD = ZERO
5. PERCENT AIR BLEED $\left(\frac{W_{b1}}{W_A}\right) = 0.5\%$
6. ROTOR SPEED = 324 RPM

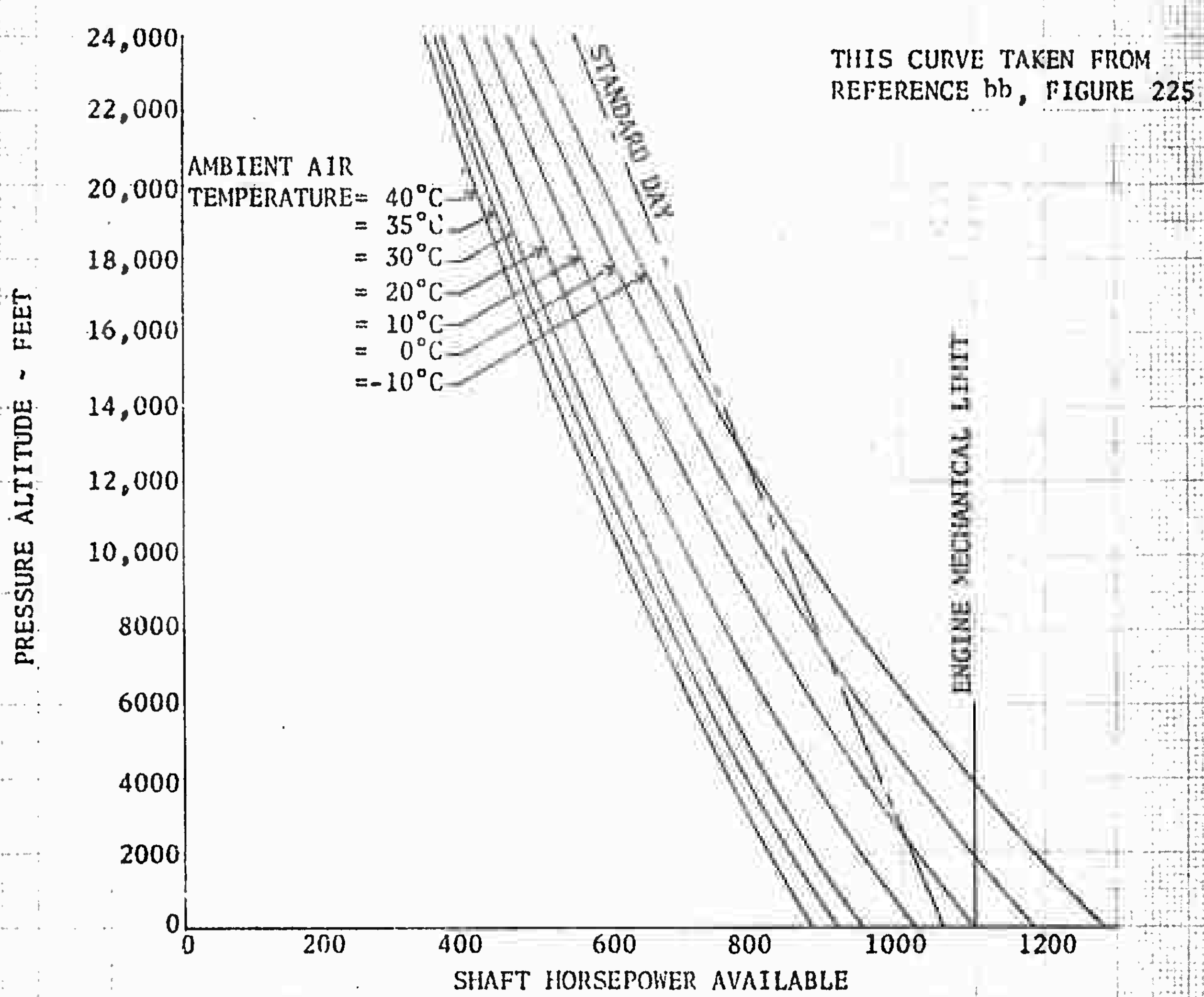


FIGURE NO. 36
C.G. STATION VS GROSS WEIGHT
UH-1B/540 USA S/N 64-14105

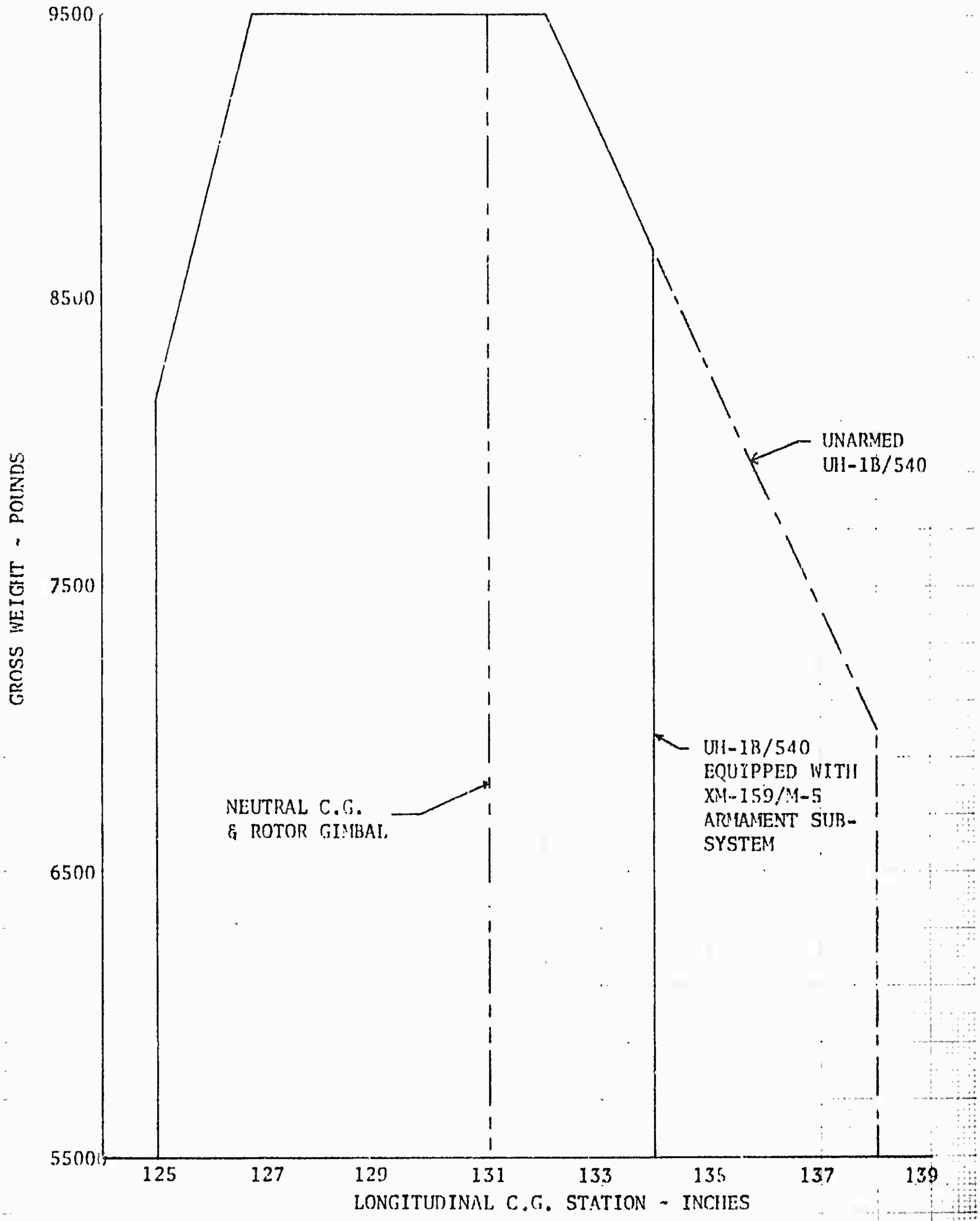


FIGURE NO. 37
TAIL BALLAST ENVELOPE
FUSELAGE STATION 425
UH-1B/540 USA S/N 64-14105

NOTE: This curve taken
from Reference z

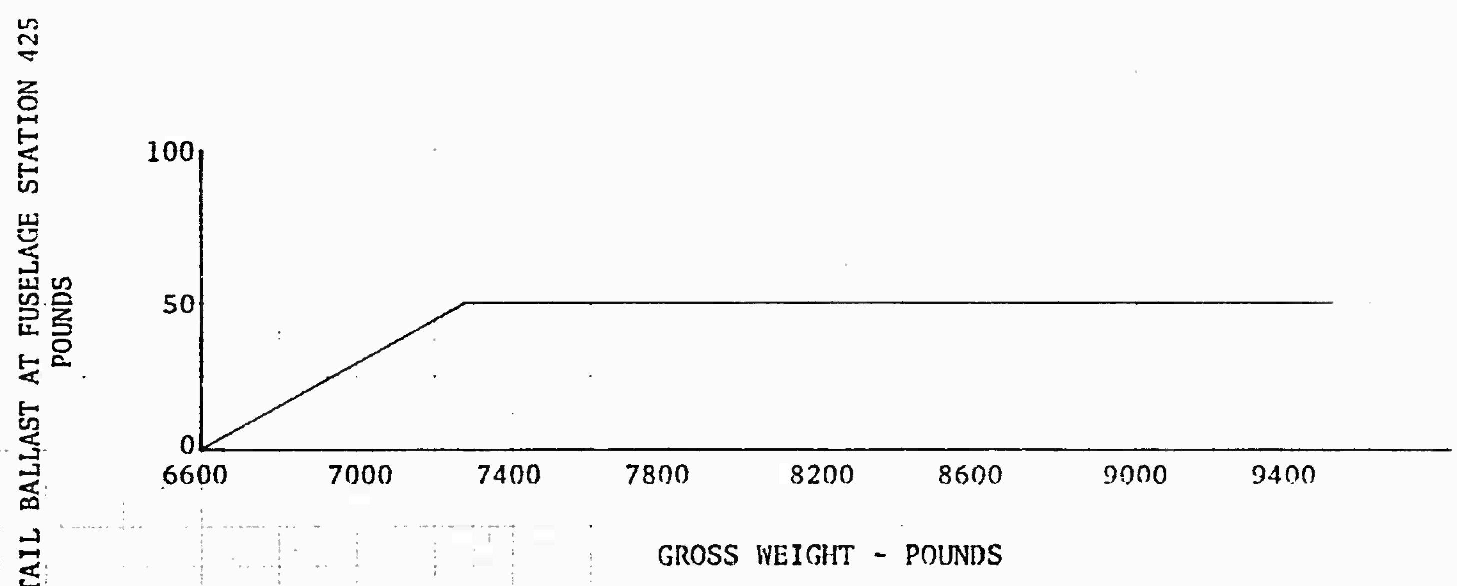


FIGURE NO. 32
SIDESLIP LIMITS
UH-1B/540 USA S/N 64-14105

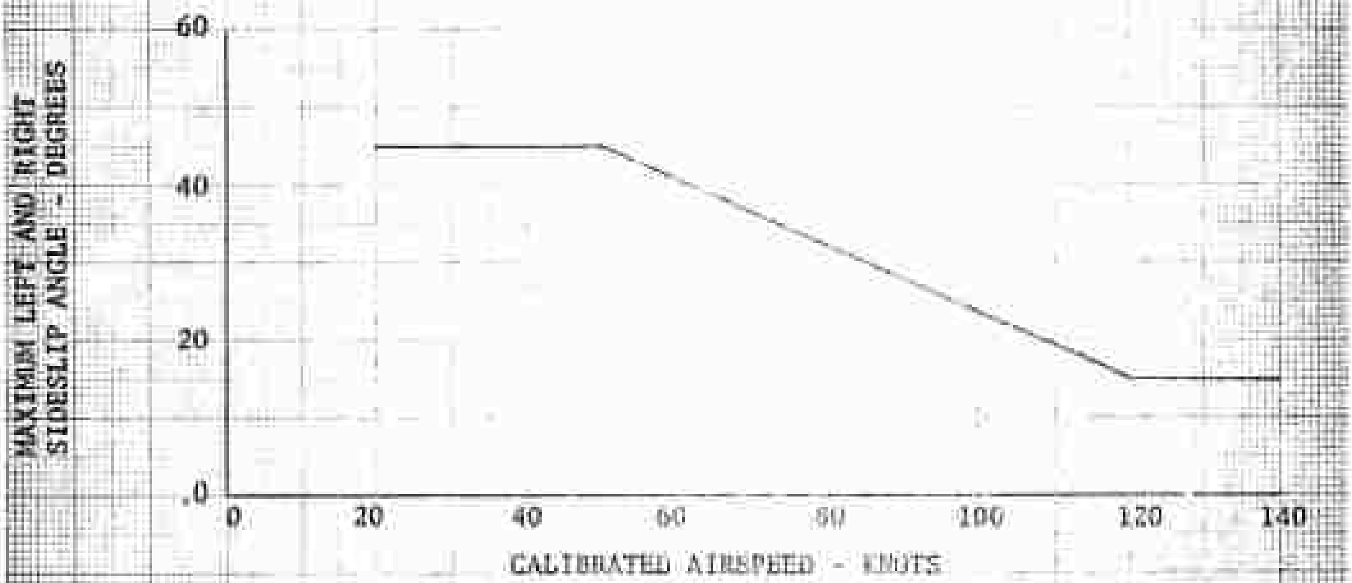
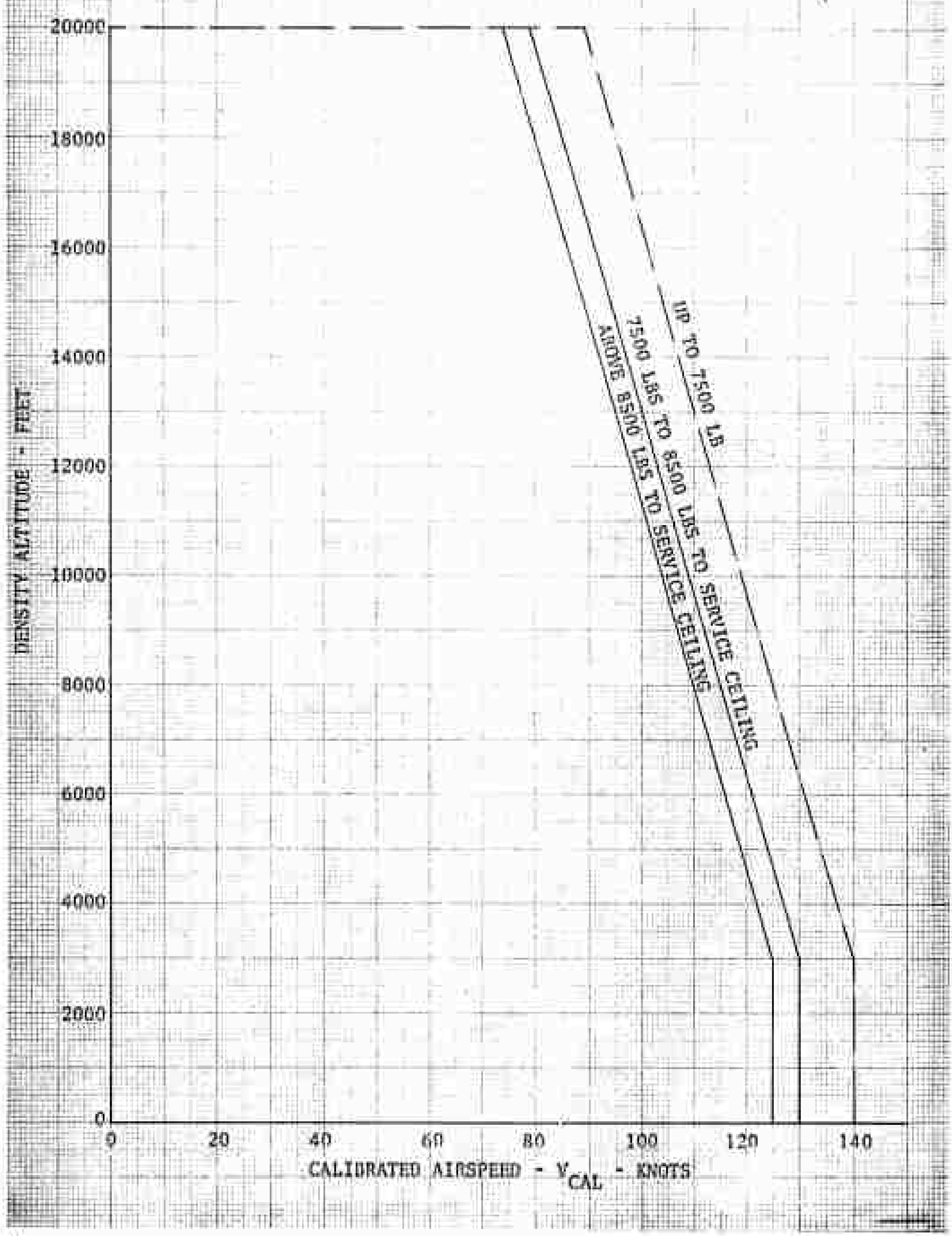


FIGURE NO. 39
V_{NE} LIMITS VS DENSITY ALTITUDE
UH-1B/540 USA S/N 64-14105



APPENDIX II TEST METHODS and DATA REDUCTION PROCEDURES

1.0 GENERAL

The equations and analysis method used to correct the performance of the helicopter to standard-day conditions are briefly described in this appendix.

The nondimensional parameters used for data analysis are defined as follows:

$$C_P = \frac{550 \times SHP}{\rho A (\Omega R)^3} = \text{Coefficient of power}$$

$$C_T = \frac{W}{\rho A (\Omega R)^2} = \text{Coefficient of thrust}$$

$$\mu = \frac{1.689\ V_T}{\Omega R} = \text{Tip speed ratio}$$

Where:

SHP = engine output shaft horsepower

A = total rotor disc area, ft^2

Ω = rotor angular velocity, radians/sec

R = rotor radius, ft

W = gross weight, lb

V_T = true airspeed, kt

ρ = air density, $slugs/ft^3$

This nondimensional method is useful only where blade stall or compressibility effects are not significant.

1.1 POWER DETERMINATION

The T53-L-11 gas turbine engine incorporates a hydro-mechanical torquemeter as an integral part of the reduction gearing on the compressor end of the engine. This torquemeter is essentially a piston that supplies pressure, in proportion to the output torque, on the hydraulic oil contained in a cylinder. To obtain a more accurate indication of torque, the pressure of oil vapor behind

this piston is also measured and the difference between this pressure and the hydraulic oil pressure is found. The conversion from torquemeter pressure to torque in inch-pound was obtained from the calibration run of engine S/N LE-10382.

The equation from which output shaft horsepower was determined from inflight torquemeter and rotor rpm readings was derived as follows:

$$SHP = \frac{2\pi}{12 \times 33{,}000} \times N_E \times T$$

where:

SHP = engine output shaft horsepower

N_E = output shaft rotational speed, rpm

T = output shaft torque, in-lb

The torquemeter calibration as obtained from engine calibration data indicated that torque could be determined as the following function of torque pressure:

$$T = 219.0\ \Delta P$$

where: ΔP = torquemeter pressure minus oil vapor pressure, psi
Engine output shaft rotational speed was determined from rotor speed as follows:

$$N_E = N_R \times 20.383$$

where:

N_R = rotor rotational speed (rpm)

Combining the above expressions results in the following expression for determining output shaft horsepower:

$$SHP = \frac{2\pi \times 219.0 \times 20.383 \times N_R \times \Delta P}{12 \times 33{,}000}$$

$$SHP = .07075 \times N_R \times \Delta P$$

Compressor inlet pressure or temperature instrumentation was not installed in the test aircraft. The engine installation losses noted in appendix V, paragraph bb for a UH-1B/540 rotor helicopter were assumed to apply. Based on this assumption, the

compressor inlet pressure equaled the ambient pressure and the compressor inlet temperature was 2 degrees C above the ambient temperature.

1.2 LEVEL FLIGHT AND SPECIFIC RANGE

Level flight speed power correction was derived from the C_P, C_T, μ method. Each speed power was flown at a pre-determined C_T holding rotor speed constant. This required holding constant by increasing altitude as fuel was consumed.

Test-day level flight power data at a constant airspeed was corrected to standard-day conditions by the following method: The test-day speedpower point was defined by the dimensionless parameters, C_{P_t}, C_{T_t}, and μ_t. Correction of test-day power to standard-day conditions was made holding these coefficients constant on the standard-day. It follows from this that the following relationships are true between test-day and standard-day conditions:

$$C_{P_t} = C_{P_s}, \quad C_{T_t} = C_{T_s}, \quad \mu_t = \mu_s$$

From these relationships and definitions of the particular terms, the following relationships hold:

$$W_t/\rho_t = W_s/\rho_s, \quad s = t_{Avg} \quad (W_s/W_{t_{Avg}})$$

This last relationship permits establishing the standard-day density, ρs, which is required for presenting the test-day data at a standard gross weight, W_s.

From the definition of the power coefficient, C_P, the following relationships can be derived:

$$SHP_t/\rho_t = SHP_s/\rho_s$$

$$SHP_s = SHP_t \quad (\rho_s/\rho_t)$$

This last relationship then defines the standard-day power required for flying at the same thrust, power and speed coefficient as on the test day but under standard-day conditions. Each level flight speed power point was corrected in this faction to standard-day conditions at the target gross weight.

Specific range calculations were performed using the level flight performance curves presented in figures 2 and 3, appendix I and the specification fuel-flow characteristics presented in figure 33.

$$NAMPP = \frac{V_T}{W_f}$$

where:

NAMPP = nautical air miles per pound of fuel

V_T = true airspeed in knots

W_f = fuel flow, pounds per hour

1.3 STABILITY AND CONTROL

The stability and control characteristics of the UH-1B/540 rotor helicopter are discussed in terms of static stability, dynamic stability, and controllability. These terms are defined in the following paragraph.

1.3.1 Longitudinal Trim Curves

The longitudinal trim curves were determined from the position of the longitudinal cyclic control with respect to airspeed. The collective position was treated as an independent variable. For each test point, the collective-stick position was determined from the position used in flight. A longitudinal control position-airspeed gradient obtained from the trim curves determined apparent static stability. The stability is called apparent because it is an indication of the longitudinal static stability from the pilot's viewpoint. It is not a direct measure of the speed stability or angle of attack stability of the aircraft. Longitudinal speed stability was obtained by locking the collective pitch at a trim point, then increasing or decreasing airspeed with the cyclic stick. Static lateral-directional stability was obtained by measuring control positions and bank angles during steady-state sideslips at a given airspeed. Control positions are reported in the following manner:

(a) Longitudinal and lateral cyclic stick displacement from full fwd and full left. Full cyclic stick travel were 13.11 inches and 12.40 inches respectively.

(b) Pedal displacement in inches from full left pedal. Full travel was 6.81 inches.

(c) Collective pitch position in inches from full down. Full travel was 10.55 inches.

1.3.2 Dynamic Stability

The dynamic stability of the helicopter was determined by recording aircraft behavior, displacement, rate and angular acceleration following an artificial disturbance. This artificial disturbance was the result of a pulse-type control input. The pulse input was made by rapidly displacing the control approximately 1 inch from trim position, holding for approximately 1 second, then rapidly returning to trim position and holding the control fixed. A mechanical fixture was used to guarantee precise input.

1.3.3 Controllability

Controllability was treated in two parts:

(a) Sensitivity. Sensitivity was defined as the maximum angular acceleration (degrees/second^2) of the aircraft per inch deflection of the cockpit control. Time to reach the maximum acceleration was included.

(b) Response. Response was defined as the maximum angular velocity (degrees/second) of the aircraft per inch deflection of the cockpit control. Time to reach the maximum rate was included. The control deflections were stick-fixed, sudden, step-type inputs. The step input was made by rapidly displacing the control from trim and holding the control fixed until recovery was necessary. A mechanical fixture was used to insure precise inputs.

1.4 AIRBORNE ROCKET LAUNCHER POD JETTISON TEST

Jettison testing was performed at various flight conditions to determine the jettison characteristics of the airborne rocket launcher pods (pods) and the effects of their jettison on the stability and control characteristics of the aircraft. From these characteristics a safe jettison envelope was developed. A build up to the more critical flight conditions was necessary. The criteria used to close the jettison envelope was pod instability after release or unacceptable damage from strikes of the pod on any component of the aircraft. High speed cameras were strategically mounted on the helicopter to record the actions of the pods after jettison. A chase aircraft was used on all jettison tests with an aerial photographer to provide air-to-air coverage. The test was initiated in a hover, progressed to various level flight trim speeds, then to various sideslip angles

at their trim airspeed, and finally to high power descents to V_{NE} and autorotations. Careful analysis of the photographic data was conducted between each successive data point. For each jettison test, the helicopter was stabilized on the desired trim condition and all parameters held constant. As the pods were jettisoned, the aircraft controls were held fixed and the oscillograph actuated to record pitch, roll, and yaw attitudes, rates, and accelerations caused by jettison of the pods. Depending upon the test airspeeds and loading condition of the pods they were normally recoverable by parachute carried in a cannister on the tail skid. Parachute use was avoided in autorotation jettisons due to the proximity of the parachute to the tail rotor.

1.5 ROCKET FIRING TEST

Firing testing was conducted to determine the effect of rocket firing on the stability and control characteristics of the helicopter. A build up to the most critical flight conditions was necessary. Static firings were conducted on the ground first to assure that sufficient clearance was provided between the fired rockets and any components of the helicopter. Six-inch clearance was the accepted minimum clearance between any component of the fired rocket and any component of the helicopter. Firings were then conducted at various level flight conditions. They were started at what was considered the least critical condition and were built up to the most critical conditions. A build up in the number of rocket pairs rippled and the rates at which they were rippled was also conducted. The helicopter was stabilized on the desired trim conditions and all parameters held constant during the firing tests. As the rockets were fired the pilot's controls were held fixed. The oscillograph was actuated to record pitch, roll, and yaw attitudes, rates and accelerations caused by the firing of the rockets.

APPENDIX III AIRCRAFT and ARMAMENT DESCRIPTION

1.0 AIRCRAFT DIMENSIONS AND DESIGN DATA

a. Over-all Dimensions

Aircraft length (nose to tail skid)	39.5	ft
Aircraft length (rotor turning)	52.9	ft
Width of skids	8.4	ft
Width (at horizontal stabilizer)	9.3	ft
Height (to top of turning tail rotor)	14.7	ft
Height (to top of rotor mast)	12.7	ft

b. Main Rotor

Number of blades	2	
Rotor diameter	44	ft
Rotor solidity	0.0652	
Disc area	1520	sq ft
Blade area (total)	99	sq ft
Blade chord (root to tip)	27	in
Blade airfoil (root to tip)	9 1/3	Special Symmetrical Section
Blade twist	-10	deg
Flapping angle	±12	deg
Collective pitch angle (75% radius)	0 to 20	deg
Preconing angle	2 3/4	deg

c. Tail Rotor

Number of blades	2	
Rotor diameter	8.5	ft
Rotor solidity	0.105	
Disc area	56.7	sq ft
Blade area (total)	5.96	sq ft
Blade chord (root to tip)	8.41	in
Blade airfoil (root to tip)	NACA 0015	
Blade twist	0	deg
Flapping angle	± 8	deg

d. Gear Ratios

Power turbine to engine output shaft	3.2057 to 1
Engine output shaft to main rotor	20.3835 to 1
Engine output shaft to tail rotor	3.9902 to 1

e. Power On Speeds

Power On Speeds	Design Maximum		Design Minimum	
Engine output shaft	6600	rpm	6000	rpm
Main rotor	323.8	rpm	294.5	rpm
Tail rotor	1654.1	rpm	1503.7	rpm
Main rotor tip	746	ft/sec	678	ft/sec
Tail rotor tip	736.1	ft/sec	669.0	ft/sec

2.0 POWER PLANT

The test aircraft was powered by a T53-L-11 gas turbine engine, S/N LE-10382. This engine is of the free-power turbine design. It consists of a reduction gear section, a five-stage axial one-stage centrifugal compressor, a diffuser, a combustion chamber, a first-stage turbine, a second-stage turbine (free-power), a power-shaft and an exhaust diffuser. The first-stage turbine drives the compressor and the second-stage turbine drives the power shaft. The power shaft extends coaxially through the compressor rotor and drives the reduction gearing at the forward end of the engine. Power for the main rotor is extracted through an internally-splined output gear shaft driven by the two-stage planetary reduction gearing. Power for the tail rotor is supplied from a takeoff on the lower end of the main rotor transmission. The engine has an output shaft operating range from 6000 rpm to 6600 rpm. The engine manufacturers guaranteed power ratings are at 6610 rpm and standard-day sea-level conditions. The guaranteed ratings are 1100 shaft horsepower (SHP) for takeoff power, 1000 SHP for military power and 900 SHP for normal rated power.

3.0 ROTOR AND CONTROL SYSTEM

The model 540 "door hinge" two-bladed, teetering, semi-rigid rotor system incorporates a flex beam hub by which the system attains a stiff chordwise or in-plane structure with a soft flapping or beam structure. The broad, flat steel plate replaces the standard UH-1B round hub spindle. This high in-plane stiffness permits the use of a large amount of tip weight without an increase in the chord oscillatory loads. The tip weight, in connection with the hub flexure reduces the beam oscillatory load. This is intended to result in a dynamically balanced design which minimizes oscillatory stress levels and rotor-induced vibrations. The main rotor blade chord has been increased to 27 inches. The rotor remains at 44-foot diameter and features a 10-degree blade twist. The airfoil section is NACA 9 1/3% which is thinner than the 12% used on all other UH-1 helicopters. Each blade has a 35 lb trim weight and a 20 lb weight installed in the leading edge "C" spar section.

The rotating controls are similar to standard UH-1B/D controls, except they have been appropriately strengthened to resist

the higher control loads encountered at the increased airspeeds and gross weight limits established for the UH-1B/540 aircraft. A collective friction device which is designed to reduce helicopter 1/rev vibrations has been installed.

4.0 TRANSMISSION ASSEMBLY

The transmission used in the UH-1B/540 helicopter is the same as the standard UH-1B transmission except for the quill assembly that drives the dual hydraulic system pumps.

5.0 DUAL HYDRAULIC BOOST SYSTEM

The dual hydraulic boost system used in the UH-1B/540 aircraft is independent of the engine. Each system is completely independent of the other except that the hydraulic pumps are driven by the same transmission quill shaft. This system features independent dual reservoirs, pumps, tandem servo-actuators, filters, switches, valves, pressure indicators and associated tubing and hydraulic lines. The pumps of both systems are powered by the main rotor. System No. 1 actuates any armament system requiring hydraulic power. System No. 2 actuates the anti-torque boost cylinder for tail rotor control.

6.0 TAIL BOOM

The tail boom is the same as that of the standard UH-1B except for added camber on the trailing edge of the vertical fin and the incorporation of the UH-1D synchronizing elevator with a protective shield on the leading edge.

7.0 TAIL ROTOR HUB AND BLADE ASSEMBLY

A modified tail rotor hub assembly is used for the UH-1B/540 aircraft to withstand the higher tail rotor assembly loads encountered at higher airspeeds. This hub is similar to the standard UH-1B/D aircraft hub except that the inboard bearing has been replaced by a thrust unit to reduce system chord loads.

8.0 AIRSPEED SYSTEM

The standard UH-1B airspeed system with independent static and dynamic parts has been replaced by an integral static dynamic pitot tube, located on the cabin roof.

9.0 XM-158 AIRBORNE ROCKET LAUNCHER PODS

The 7-round, reusable 2.75-inch XM-158 airborne rocket launcher pod consists of 7 aluminum rocket tubes bound together by a

stainless steel clamping band over each of 2 sets of cast aluminum support segments. No external housing or fairing is incorporated. An electrical firing contact is at the rear of each tube. The launcher is the single-fire open-breech tube type. Mounting lugs are attached to the clamping bands and spaced 14 inches apart to accommodate mounting from the XM-156 multiarmament helicopter mount. The launcher fires 7, 2.75-inch limited-spin folding fin aerial rockets (LSFFAR's) with the XM-151 high explosive warhead. It is also capable of firing other types of rockets such as smoke and white phosphorous rockets.

Data on the XM-158 airborne rocket launcher pods follows:

Length - overall	53 3/4 in
Cross section	9 7/8 in diameter
Capacity (2.75-inch/LSFFAR)	7
Weight - empty	39 lb
Weight - loaded	168.5 lb
Ignition	28 volt DC

One airborne rocket launcher pod is mounted on each side of the helicopter providing a total capability of 14 rockets. The airborne rocket launcher attitude is of fixed design and can be changed in elevation or deflection only on the ground. No azimuth adjustment is provided except for small changes to allow boresighting. The 2.75-inch LSFFAR's can be fired in ripples only and are ignited in pairs, one rocket simultaneously from each airborne rocket launcher pod. Up to 7 pairs of rockets may be selected on the cockpit armament control panel. The rockets fire at a preset ripple rate of 6 rockets per second. The rocket firing button is located on the center left side of the pilot's cyclic control stick. The XM-60 sight is used with this launcher. The launcher can be jettisoned manually or electrically. A normal operating

armed mission weight of the XM-158/M-5 used in conjunction with the XM-16 or XM-21 armament subsystem is shown as follows:

	WEIGHT POUNDS
Basic aircraft	4950
Armored seats	330
M-5 grenade launcher, operating equipment, sight, and 150 rounds ammunition	340
Pilot and copilot at 200 lbs each	400
242 gal fuel at 6.5 lb/gal	1573
XM-16 or XM-21 armament subsystem with external and internal components installed including 600 rounds of ammunition and 14 rockets	1097
Engine start gross weight	8652

10.0 XM-159 AIRBORNE ROCKET LAUNCHER PODS

The 19-round, reusable, 2.75-inch XM-159 airborne rocket launcher pod, P/N 64C114J1, consists of 19 aluminum rocket tubes encased in a cylindrical aluminum housing or fairing with an electrical firing contact at the rear of each rocket tube. The airborne rocket launcher is the single-fire open-breech tube type. Mounting lugs are spaced 14 inches apart to accommodate mounting from the XM-156 multiarmament helicopter mount. The launcher fires 19, 2.75-inch LSFFAR's utilizing the XM-151 rocket high explosive warhead. It is also capable of firing other types such as smoke and white phosphorous rockets.

One pod is mounted on each side of the helicopter providing a total capability of 38 rockets. The launcher attitude can be adjusted in elevation and deflection on the ground. Firing at an adjustment other than maximum elevation (+6 degrees elevation relative to helicopter waterline) will not give sufficient skid-tube clearance for rockets. No azimuth adjustment is provided except for small changes to allow boresighting. The 2.75-inch LSFFAR's can be fired in ripples only and are ignited in pairs, one rocket simultaneously from each airborne launcher pod. Up to 7 pairs of rockets may be selected on the cockpit armament control panel. The rockets fire at a preset ripple rate of 6 rockets per second. The rocket firing button is located on the center left side of the pilot's cyclic control stick. The XM-60 sight is used with this launcher. The launcher can be jettisoned manually or electrically.

Following is the data on the XM-159 airborne rocket launcher pods:

Length - overall	49.87 in
Cross section	15.5 in diameter
Capacity (2.75-inch LSFFAR)	19
Weight - empty	95.5 lbs
Weight - loaded	447 lbs
Suspension	Lugs center and 14 in forward
Ignition	28 volt DC
Operating temperature range	-53.9 deg C to +73.9 deg C

When the XM-159 airborne rocket launcher pods are used on the UH-1B/540 rotor helicopter with the XM-156 multiarmament helicopter mount, 4-inch cast aluminum spacers must be installed between the universal external stores pylon support assembly and the XM-156 multiarmament mount and support assembly to provide minimum safe clearance from the skid tube for fired rockets. The manual jettison cables must be lengthened 4 inches when the spacers are in-

stalled. A normal operating armed mission weight of the XM-159/M-5 armament subsystem follows:

	WEIGHT POUNDS
Basic aircraft	4950
Armored seats	330
M-5 grenade launcher, operating equipment, sight, and 150 rounds ammunition	340
Pilot and copilot at 200 lbs each	400
242 gal fuel at 6.5 lb/gal	1573
Launcher racks, support assembly, operating equipment, and XM-60 sight	162
Two loaded XM-159 rocket launcher pods	894
Engine start gross weight	8649

11.0 XM-156 MULTIARMAMENT HELICOPTER MOUNT

The XM-156 multiarmament helicopter mount is a combination of items that provide rocket fire capability for the UH-1B and UH-1B/540 rotor helicopters. It consists of a rack and support assembly (figure E) mounted externally on each side of the heli-

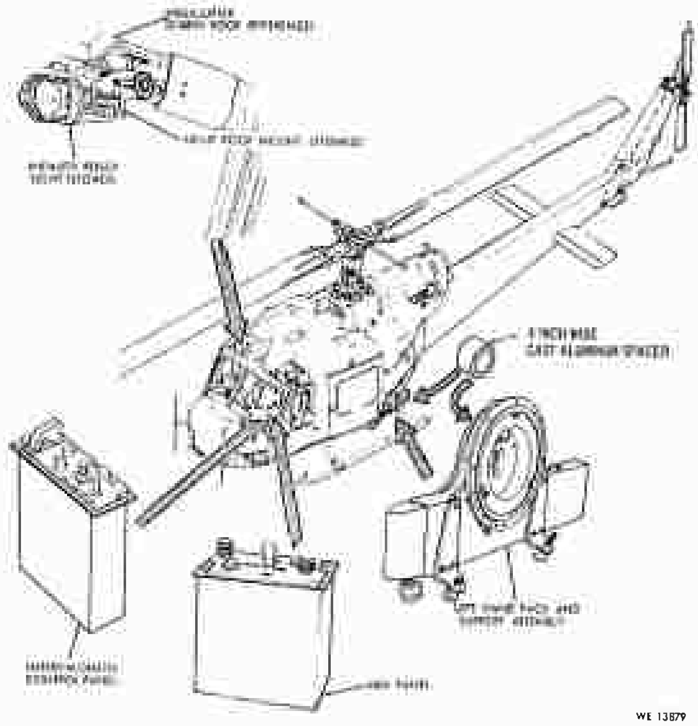


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FIGURE E COMPONENTS OF HELICOPTER MULTIARMAMENT MOUNT LOCATED ON UH-1C HELICOPTER

copter, capable of carrying and firing the 2.75-inch XM-157, XM-158, and XM-159 airborne rocket launcher pods. These pods all carry 2.75-inch LSFFAR rockets. The XM-156 multiarmament helicopter mount is also capable of carrying other armament or stores, limited to 505 lbs per side, from its 14-inch spaced suspension hooks. The XM-16 and XM-21 are two such systems. In addition to a rack and support assembly, the XM-156 consists of a rocket launcher arm panel, rocket launcher intervalometer, XM-60 infinity reflex sight, infinity sight mount, connecting cable assemblies and mechanism for manual or electric jettison of launchers. The arm panel is designed for use with airborne rocket launcher pods and controls the electrical power of the armament system through the OFF-SAFE-ARMED switch (figure E). The intervalometer controls rocket firing circuits and is interconnected electrically with the arm panel (figure E). The infinity sight XM-60 provides projected reticle image enabling the pilot to fly a target-collision course by maintaining the target at the center of the infinity sight reticle pattern (figure E).

Tabulated data on the XM-156 multiarmament helicopter mount is presented below:

Rack and support elevation and depression adjustment limit	± 103.7 mills (5.8 degrees)
Rack and support assenbly	65.50 lb
Infinity sight XM-60	9.10 lb
Intervalometer	2.40 lb
Arm panel	1.35 lb
Cable assemblies	approx 5.0 lb

It is necessary to modify the XM-156 multiarmament helicopter mount when used on the UH-1B/540 rotor helicopter with the XM-159 rocket launcher pod. This may be done by installing 4-inch cast aluminum spacers between the universal external stores pylon support assembly and the XM-156 rack and support assembly (figure E). The manual release jettison cable must also be lengthened 4 inches. Insufficient rocket-to-helicopter skid tube clearance exists when rockets are fired without spacers therefore, these modifications are required.

APPENDIX IV INSTRUMENTATION

Calibrated instruments were installed and maintained by USAAVNTA. The following parameters were recorded:

a. PILOT'S PANEL

Sensitive Rotor Speed
Boom System Airspeed
Boom System Altitude
Angle of Sideslip
Angle of Attack
Longitudinal Cyclic Stick Position
Lateral Cyclic Stick Position
Collective Stick Position
Pedal Position

b. ENGINEER'S PANEL

Standard System Airspeed
Standard System Altitude
Torque (High and Low)
Free Air Temperature
Fuel Flow
Fuel Total
"G" Forces
Oscillograph Counter

c. OSCILLOGRAPH

Pilot's Event
Engineer's Event
Longitudinal Cyclic Stick Position
Lateral Cyclic Stick Position
Pedal Position
Collective Stick Position
Rotor Blip
C.G. Normal
Angle of Attack
Angle of Sideslip
Pitch Angle

Pitch Rate
Pitch Acceleration
Yaw Angle
Yaw Rate
Yaw Acceleration
Roll Angle
Roll Rate
Roll Acceleration
Pilot's Vertical Vibration
Pilot's Lateral Vibration
Aft Bulkhead Vertical Vibration
Aft Bulkhead Lateral Vibration
Voltage
Linear Rotor RPM
A circuit was installed to produce an event mark on the oscillograph record at the time the airborne rocket launcher pods were jettisoned

APPENDIX V REFERENCES

a. Letter, AMSTE-BG, Hq, U. S. Army Test and Evaluation Command (USATECOM) 4 August 1965, subject: "Test Directive, USATECOM Project Nos. 4-4-1542-04/05/06, Engineering and Service Test of 7-Tube, Reusable, 2.75, FFAR Launcher Pod, DA Project No. 1X141006D134.04."

b. Plan of Test, "Engineering Test of Armament Subsystem Installed on UH-1B/540 Rotor Helicopters," U. S. Army Aviation Test Activity (USAAVNTA), August 1965.

c. Letter, STEAV-PO, USAAVNTA, 25 August 1965, subject: "Proposed Plan of Test of Armament Subsystems Installed on UH-1B/540 Rotor Helicopters, USATECOM Project No. 4-5-1591-01, USAAVNTA Project No. 65-12."

d. Unclassified Message SMOSM-EAA 9-1340, Hq, U.S. Army Aviation Materiel Command (USAAVCOM), 9 September 1965, subject: "UH-1B (540 Rotor) Armament Flight Release."

e. Letter, STEAV-PO, USAAVNTA, 13 September 1965, subject: "Engineering and Service Test of XM-158, USATECOM Project No. 4-4-1542-06."

f. Unclassified Message SMOSM-EAA 9-1467, Hq, USAAVCOM, 1 October 1965, subject: "UH-1B (540 Rotor) Armament Airworthiness Flight Release."

g. Letter, AMSTE-BG, Hq, USATECOM, 15 October 1965, subject: "Product Improvement Test of Aircraft Armament Subsystems Installed on UH-1B/540 Rotor Helicopter, USATECOM Project Nos. 4-5-1591-01/02/03."

h. Letter, AMSTE-BG, Hq, USATECOM, 7 December 1965, subject: "Test Plan Approval, USATECOM Project No. 4-5-1591-01."

i. Unclassified Message 00491, STEAV-FT, USAAVNTA, 30 September 1966, subject: "Jettison Envelope for XM-158 Rocket Pods Suspended from XM-156 Multiarmament Mount M-5 Grenade Launcher Equipped UH-1B/540 Helicopter."

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l. Letter, AMSTE-BG, Hq, USATECOM, 12 July 1966, subject: "Amendment to Directive for Engineering Service Test of XM-159 Pod for 2.75-Inch FFAR."

m. Letter, STEAV-PO, USAAVNTA, 19 July 1966, subject: "UH-1B/540 Armament Systems Test," with 1st Indorsement, AMSTE-BG, Hq, USATECOM, 27 July 1966.

n. Unclassified Message SMOSM-EAA-7-1380, Hq, U. S. Army Aviation Materiel Command (USAAVCOM), 23 July 1966, subject: "Airworthiness Flight Release for Testing XM-156 Helicopter Armament Mount and XM-159 Rocket Pod."

o. Unclassified Message SMOSM-EAA-8-1302, Hq, USAAVCOM, 28 July 1966, subject: "XM-156 Helicopter Armament Mount and XM-159 Rocket Pod."

p. Letter, STEAV-PO, USAAVNTA, 2 August 1966, subject: "Engineering Plan of Test of UH-1B/540 Rotor Helicopter with XM-159 Airborne Launcher Installed."

q. Letter, AMSTE-BG, Hq, USATECOM, 19 August 1966, subject: "Test Plan of UH-1B/Rotor Helicopter with XM-159 Airborne Rocket Launcher Installed (U)."

r. Letter, AMSTE-BG, Hq, USATECOM, 25 October 1966, subject: "XM-159 Airborne Rocket Launching Testing."

s. Unclassified Message, STEAV-FT 00434, USAAVNTA, 31 August 1966, subject: "Suspension of Testing of XM-159 Armament System on UH-1B/540 USATECOM Project No. 4-4-1542-09."

t. Unclassified Message AMSAV-EAA-9-1336, USAAVCOM, 9 September 1966, subject: "XM-156 Helicopter Mount and XM-159 Rocket Pod."

u. Unclassified Message APG 16176, AMSTE-BG, Hq, USATECOM, 17 September 1966, subject: "XM-156 Helicopter Armament Mount on XM-159 Rocket Pod."

v. Unclassified Message STEAV-FT 00495, USAAVNTA, 4 October 1966, subject: "Interim Letter Report and Recommendation for Safety-of-Flight Release of XM-159, 2.75-Inch FFAR Airborne Rocket Launcher Suspended from an M-5 Equipped UH-1B/540 Helicopter."

w. Unclassified Message STEAV-FT 00521, USAAVNTA, 18 October 1966, subject: "XM-159 Airborne Rocket Launcher Testing."

x. Technical Manual TM-55-1520-211-10, "Operator's Manual, Army Models UH-1A and UH-1B Helicopter," Department of the Army, 29 July 1964.

y. Military Specification MIL-H-8501A, "General Requirements for Helicopter Flying and Ground Handling Qualities," Revised January 1961 and Amended 3 April 1962.

z. Unclassified Message SMOSM-EAA-9-1340, USAAVCOM, 9 September 1965, subject: "UH-1B (540 Rotor) Armament Flight Release."

aa. Final Report, USAAVNTA, June 1966, "Engineering Evaluation of UH-1B Helicopter Equipped with Model 540 Rotor System, Phase B."

bb. Final Report, USAAVNTA, December 1966, "Engineering Test of the UH-1B Helicopter Equipped with the Model 540 Rotor System, Phase D."

cc. Final Report, USAAVNTA, January 1967, "Engineering Flight Test of UH-1B/540 Rotor Helicopter Equipped with XM-16/M-5, XM-21/M-5, or XM-3/M-5 Armament Subsystem."

dd. Unclassified Message, AMXLE-FT 12-18339, Letterkenny Army Depot (LEAD), 5 December 1966, subject: "New Model Designation For Army Aircraft."

ee. Military Specification MIL-I-6115A, "Installation of Pitot Tube and Flush Static Port Operated Instrument Systems," 31 December 1960.

APPENDIX VI SYMBOLS and ABBREVIATIONS

Symbols and Abbreviations	Definition	Units
A	Rotor Disc Area	ft^2
C.G.	Center of Gravity	in
C_P	Power Coefficient	Nondimensional
C_T	Thrust Coefficient	Nondimensional
freq	Frequency	cycles/sec
IGE	In Ground Effect	--
KCAS	Knots Calibrated Airspeed	kt
KIAS	Knots Indicated Airspeed	kt
KTAS	Knots True Airspeed	kt
NAMPP	Nautical Air Miles per Pound of Fuel	--
N_R	Rotor Rotational Speed	rpm
N_E	Output Shaft Rotational Speed	rpm
R	Rotor Radius	ft
R/D	Rate of Descent	fpm
rd/min	Rounds per Minute	--
rpm	Revolution per Minute	rpm
S.A.	Single Amplitude	g
SHP, shp	Shaft Horsepower	ft-lb/min
T	Output Shaft Torque	in-lb
V_{NE}	Airspeed Not to Exceed	kt
W_f	Fuel Flow	lb/hr

Symbols and Abbreviations	Definition	Units
1/rev	Cycles per Rotor Revolution (Vibrations)	cycles/rev
δ	Pressure Ratio	--
ΔP	Torque Differential Pressure	psi
μ	Rotor Tip Speed	Nondimensional
Ω	Angular Velocity	radians/sec
ρ	Air Density	slugs/ft^3
θ	Temperature Ratio	--

Subscript		
s	Standard-Day Conditions	
t	Test Conditions	
T	True Airspeed	

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DOCUMENT CONTROL DATA - R&D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1 ORIGINATING ACTIVITY (Corporate author) U. S. Army Aviation Test Activity (USAAVNTA) Edwards Air Force Base (EAFB), California 93523	2a REPORT SECURITY CLASSIFICATION UNCLASSIFIED 2b GROUP

3 REPORT TITLE Engineering Flight Test of the UH-1C Helicopter Equipped with the M-5 Grenade Launcher and the XM-158 or XM-159 Airborne Rocket Launcher Pods Suspended from the XM-156 Multiarmament Mount.

4 DESCRIPTIVE NOTES (Type of report and inclusive dates)
Final Report, 1 August 1966 through 25 October 1966

5 AUTHOR(S) (Last name, first name, initial)
Jerry W. Petrie, Project Engineer
Gary C. Hall, Major, U.S. Army, TC, Project Pilot

6 REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
February 1967	95	30

8a CONTRACT OR GRANT NO. b. PROJECT NO. RDT&E Project Number 1X141806D13404 c. USATECOM Project Nos. 4-4-1542-06 d 4-4-1542-09	9a. ORIGINATOR'S REPORT NUMBER(S) USAAVNTA Projet Nos. 65-12, 66-09 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) N/A

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	Weaponization Project Manager U.S. Army Materiel Command

13 ABSTRACT Presented are the results of engineering flight test of the UH-1C (UH-1B/540 rotor) helicopter equipped with the M-5 grenade launcher and the XM-158 or XM-159 airborne rocket launcher pods suspended from the XM-156 multiarmament helicopter mount. Testing was conducted at Edwards AFB, Fort Irwin and Bakersfield, Calif. Eighty-five flights for a productive flight time of 48 hours were flown on UH-1B/540 S/N 64-14105 between 1 August 1966 and 25 October 1966. Tests included 32 jettison flights for the XM-158 pods, 20 jettison flights for the XM-159 pods and 16 firings of the XM-159 pods. The objective was to determine quantitative effect of the XM-159 pods installed from the XM-156 mount on the stability, control and performance of the helicopter; to determine the XM-158 and XM-159 pod jettison characteristics and define the flight envelope for safe jettison of the pods; and to determine the flight envelope for firing the XM-159 pods. There were no significant adverse changes in the stability and control characteristics of the UH-1B/540 due to the installation of the XM-159. Previously reported longitudinal dynamic instability in climbs was also present throughout the tests Self-excited undamped lateral 2/3-per-rev vibration was prevalent during the tests. Safety-of-flight implications due to this condition should be investigated and corrected, if necessary. Insufficient rocket-to-aircraft clearance for firing the XM-159 on the XM-156 mount was present without the addition of 4-inch cast aluminum spacers between the XM-156 mount and the universal pylon The XM-159 was adjusted to maximum elevation to provide sufficient clearance for firing with the spacers installed. No major stability and control problems were encountered during the firing tests of the XM-159 or during the jettison tests of both the XM-158 and XM-159 Recommended flight envelopes were developed for jettison of both systems.

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14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Engineering Flight Test						
Stability & Control Test						
Performance Test						
Jettison Test						
Firing Test						
UH-1C (UH-1B/540) Helicopter						
M-5 Grenade Launcher						
XM-158 Rocket Launcher						
XM-159 Armament Subsystem						
XM-156 Multiarmament Mount						

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